RESEARCH IN AVIATION MEDICINE FOR THE GERMAN AIR FORCE

1945

COMBINED INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

CONFIDENTIAL

RESEARCH IN AVIATION MEDICINE

FOR THE GERMAN AIR FORCE

Reported By

Colonel W. R. LOVELACE II, M.C.
U. S. Army Air Force

CIOS Item Number 24
Medical

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear) APO 413

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Personnel of Team

Colonel W. R. LOVELACE, CIOS
Lieutenant W. J. WULFF, CIOS

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AIR TECHNICAL SERVICE COMMAND

MEMORANDUM REPORT

Aero Medical Laboratory

Wright Field, Dayton, Ohio

4 July 1945

SUBJECT: Evaluation of Targets Investigated and Summary of Information Obtained Pertaining to Research in Aviation Medicine for the German Air Force.

PURPOSE: To report the results of the investigation of the activities and the results of institutions and personnel engaged in physiological, medical and engineering research for the German Air Force for the purpose of improving aircrew efficiency and safety.

FACTUAL DATA:

1. Investigation of German research institutions, personnel and manufacturing facilities was carried out in accordance with Letter Orders A5-2-15 dated 2 May 1945 and letter of instructions attached to this report as Appendix I.

Upon reporting to the Directorate of Intelligence, USSTAF, additional orders and transportation were obtained to make possible an extended field trip into Germany under the auspices of Air Technical Intelligence. Intelligence information, i.e. location of targets and their value and other valuable information were obtained from Director of Medical Services, Aero Medical Research Section, USSTAF (Rear), Major W. F. Sheeley and his staff and from Air Technical Intelligence personnel particularly Captain Pforzheimer.

2. The manufacturing facilities and institutions visited are listed with a short description of new equipment and significant research.

2.1 Draegerwerke, Lübeck visited from 5/16/45 to 5/23/45.

2.11 Personnel Interrogated were:

Dr. Hermann Draeger
Dr. Ing. Franz Hollmann
Dr. Ing. Cordes
Dipl. Ing. Hermann Tietze

2.12 The results of the interrogation are described in detail in the interrogation report attached as Appendix II. The following developments are listed as new and interesting.

2.121 Ball bearing flexible joints for positive pressure suits.

2.122 Extremely high capacity reducing regulators for actuating pilot ejections seats and for submarine applications.

2.123 Demand regulators with a positive pressure overide actuated by the supply pressure.

2.124 A manometric method for the measurement of carbon dioxide concentrations.

2.125 A method, using a differential thermometer, for the measurements of carbon monoxide concentrations.

2.13 The new items of production equipment which were evacuated are:

2.131 An independent oxygen supply system for use during parachute escape. This system consisted of a series of small cylinders arranged in the form of a flat plate. The metering orifice is a long copper tube. The entire system fits into a special pocket in either the back or seat type parachutes.

2.132 Molded (buna S) oxygen masks copied after the AAF oxygen mask type A-14.

2.133 A portable manometric method for the measurement of CO_2.

2.134 A portable carbon monoxide indicator.

2.2 Luftfahrtforschungsanstalt Hermann Göring, Volkenrode near Brunswick.

2.21 Personnel interviewed

Prof. Dr. A. Busemann
Dr. Ing. W. Knackstedt

2.22 Results of interrogation

The results of the interrogation are summarized in Appendix III. This institute was primarily

concerned with aerodynamics. A series of experiments were made on human subjects to determine the effect of high wind velocities on the human face and chest. The results, contained in the report "Untersuchungen am menschlichen Körper bei hohen Standrucken" L.F.A., H.G., indicate that velocities up to 410 mph can be tolerated safely for one or two seconds, with a maximum of 5 seconds. Measurements of ram pressures were made at various points on a model face. Later humans were tested in wind velocities up to 510 mph. Additional information is contained in the abstracts of articles summarized in Appendix IV. In general the results indicate that: 1) wind velocities up to 530 miles per hour can be sustained for 1 to 2 seconds exposure; 2) breathing is altered because of the positive ram pressure and becomes shallow and irregular; and 3) use of interference boards behind the head to offset this ram pressure.

2.3 Medical Research Institute at Garmisch-Partenkirchen (formerly at University of Munich)(CIOS Trip 419)

2.31 The following personnel were interrogated

Dr. Ulrich Henschke
Dr. Wolf. Dieter Keidel
Dr. Siegfried Gerathewohl
Dr. Ado Frank
Dr. Fritz Hollwich

2.32 The results of the interrogation are summarized in Appendix V Ex A. The outstanding characteristic of the work at this institute is the approach to aviation medical problems; it is essentially liaison work between the pilot or aircrew personnel and the machine they are operating, to improve the efficiency of operation. As such they have investigated various methods of steering aircraft, aiming guns and remote controlled bombs and the influence of proper handle design on skill of operation. They have worked with optical devices to improve visual acuity and improve efficiency of operation. The effect of maximal accelerations which can be sustained by the human body in various positions for short time intervals, i.e. 0.01 seconds. The limitations of accelerations regardless of direction seem to be that which causes concussion of the brain. This concussion level seems to be about 10 g.

For further details on the research carried out at this laboratory, reference is made to the list of reports in Appendix V, Ex. B and the short summary of unpublished work in Appendix V, Ex. C.

2.4 Messerschmidt AG, Upper Bavarian Research Institute, Oberammergau.

2.41 Personnel Interrogated

Dipl. Ing. Waldemar Voigt
Ing. Josef Helmschrott
Ing. Walter Keidel

2.42 The results of the interrogation are summarized in Appendix VI. This firm had designed and developed pressure cabins for the Me 109, which went into production but was discontinued for lack of military requirements, and for the Me 262 which did not go into production. The pilot ejection program was only experimental.

2.5 Aero Medical Research Institute, Freising (formerly University of Munich). (CIOS Trip 419)

2.51 The following personnel were interrogated:

Dr. Wolfgang Lutz
Prof. Georg Weltz
Dr. Robert von Werz

2.52 The results of the interrogation are summarized in Appendix VII, Ex. A. It is considered important to direct attention to two general problems investigated principally by Dr. Lutz: 1) The problem of parachute escape from extremely high altitudes and the allied problem of the recovery from extremely high altitude apparent death phenomena. This work was primarily of an exploratory nature and the physiological bases and effects have to be further assessed; 2) The physiological effects of reduced body temperatures of warm blooded mammals. This investigation was more thoroughly done but many of the aspects uncovered by Dr. Lutz deserve further study.

For further detail a complete reference of available documents on these subjects are presented in Appendix VII, Ex. B. This reference includes a lecture summarizing experiments on reduced body temperatures using human prisoners at the Dachau Concentration Camp.

2.6 Aeromedical Research Institute, Brannenburg and Reichsanstalt für Hochfrequenzforschung (Helmholz Institute) on top of Mt. Wendelstein.

2.61 Personnel Interrogated were:

Dr. Hans Desaga)
Dr. Kurt Reissman : from the Medical
Dr. Josef Pichotka) Section

Dr.Ing.habil. W. Ernsthausen)
Dipl.Ing. W. von Wittern) from Helmholz Institute

2.62 The results of the interrogation are summarized in App VIII Ex. A. Attention is called to the relative importance of examining the physiologic effects of low frequency high energy vibrations such as exist in the vicinity of intermittent jet propulsion units as well as the physiologic affects of supersonic high energy vibrations which exist in high velocity jet propelled aircraft during flight. This realm of investigation was begun shortly before the end of the war for Germany and the completed research consists of physical measurement of the magnitude and the frequency of vibration from the continuous and intermittent jet engine, and from the Me 262 during flight. For further detail please refer to the reference in Appendix VIII, Ex. B.

2.7 Forschungsanstalt Graf Zepplin, near Ruit, east southeast of Stuttgart.

2.71 The following personnel were interviewed:

Dr.Ing. Helmut Heinrich
Dipl.Ing. Theodor Knacke
Prof.Dr. Georg Hans Madelung
Prof. Theodor Benzinger

2.72 The results of the interview are summarized in App IX. This institute has been active in parachute research since 1934. The personnel have been active in the aerodynamic study of parachutes of new design, e.g. the guide surface and the ribbon type chute was developed for use on aircraft because it opens very gradually and can withstand large opening forces. Both types of chutes have found wide applications. The ribbon chute was used to brake aircraft, low altitude heavy bombs and, experimentally, for high velocity parachute escape. The guide surface chute was used for guiding heavy high altitude bombs, for laying mines and launching aerial torpedoes. Development was also started on a chute with a minimal opening shock.

2.73 The interrogation of Dr. Benzinger is also summarized in Appendix IX. Dr. Benzinger has been chief of the Aeromedical Laboratory at the Experimental Station in Rechlin. As such he has dealt with the immediate problems of the pilot and members of the aircrew. He was responsible for: 1) instituting the resistance to anoxia test, which eleminated about 2 to 3% of cadets; 2) safety pressure override on demand regulator; 3) pressurized cabins rather than pressure suits; and 4) ability to withstand explosive decompression; and 5) stimulated much work on the physiology of the collapse reaction and physiological effects of reduced body temperatures.

2.8 Department of Physiology, University of Heidelberg, visited on 6/19/45.

2.81 Personnel interrogated:

Prof. Dr. J.D. Achelis - Dean of Physiology Lab.
Dr. Otto Gauer - physiologist
Dr. Hans Notdurft
Dr. K.E. Schäffer

2.82 The facilities of the laboratory included ample space, general equipment for a physiological laboratory and especially designed metabolic apparatus. In addition there is a well insulated zinc lined room for research on the influence of temperatures of +2 to 42°C. with a humidity of 58 to 90 per cent. This room contains ample leads to recording instruments on the outside.

2.83 The personnel will be interviewed at a later date by personnel of the Third Central Medical Establishment to determine type of research being carried on and the results obtained.

2.9 Kungl. Flygförvaltningen, Stockholm, Sweden. 6/25/45 to 7/1/45 (Headquarters for the Royal Swedish Air Force)

2.91 Personnel interviewed:

Lt. General B. Nördenskiöld - Commanding General
Brig. Gen'l Alfred E. Kessler - US Military Attache
Brig. Gen'l N. Söderberg - Airboard, Deputy Chief
Col. C.E. Sparre - Chief, Material Division

Lt. Col. Kjellson - Chief, Equipment Dep't
Major Aestergard - Chief, Airframe Dep't
Major Edlen - Research Dep't
Lt. E. son Falk - Chief of Section MFI
Col. E. Westerberg - The Air Surgeon
Maj. L. Westring - Assistant Air Surgeon
Capt. K. Rasmusson - Equipment Dep't
First Sgt. Boberg - Equipment Dep't
Professor Hohwii Christensen - Chief consultant in Physilogy to Royal Swedish Air Force.
Major F.A. Potter - Surgeon to American Legation

2.92 The present status of aviation medicine in the AAF and the Royal Swedish Air Force reviewed. In all instances, with the exception of seat ejection, the equipment for the AAF is superior to that used by the Swedish Air Force. For example a continuous flow oxygen system using a modified A-8 oxygen mask is used in their combat aircraft.

The AAF G suit had been examined with a great deal of interest by the above personnel in as much as it had functioned so well in combat against the German Air Force.

After numerous conferences a powder operated ejection seat used in the J-21 was obtained from the Svenska Aeroplan Aktiebolaget Company through the Royal Swedish Air Force. This is a classified project and so will be covered in detail in a separate report.

3. Summary of significant research and development

3.1 Acceleration

3.11 Pilot ejection seats. Seats for the ejection of pilots are considered essential for the following reasons: quickly to escape and safely to avoid plane structures at high speed, at all altitudes, including on the deck flight, during centrifugal force, during abnormal attitude of the aircraft, in case of damage to the aircraft or fire and when a pilot is wounded. For the above reason the Reichs Luftfahrt Ministerium in Nov 1944 issued an order to the German aircraft industry that all prototype aircraft were to have ejection seats installed. Ejection seats were tested in the following aircraft: He 162, He 219, He 280, H3 229, Me 262 and Do 335. The Royal Air Force in Dec 1944 established a requirement for seat ejection for aircraft with potential speeds of 400 or more

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miles per hour. The Royal Swedish Air Force is considering a similar requirement.

In the 8th Air Force an appreciable percentage of fighter pilots were injured when bailing out. With higher speed jet propelled aircraft many more pilots will be injured when bailing out and an appreciable percentage will be unable to escape from such aircraft in an emergency.

3.111 Since the effect of accelaration on human beings depends on the magnitude, duration and direction of force the sequence of events during pilot ejection is important. First there is the acceleration during the start from seat to head of 10 to 20 G (27 G nomintarily in the Do 335) lasting for 0.1 to 0.2 seconds, followed immediately by the ram pressure of the air outside the cockpit with a force acting in the chest to back direction of 10 to 15 G. At the same time the down draft produces an acceleration in the direction from the head to seat which reaches a maximum of 6 to 10 G and returns to 0 G in 1 to 2 seconds. Experiments have demonstrated that an acceleration of 20 G which produces a force acting in the direction head to foot and lasting 0.1 sec can be tolerated by an average man provided an abdominal and shoulder harness is used to prevent bending of the upper portion of the body with resultant fracture of the vertebra. Henschke has found that 36.5 G. is safe for 1/100 of a second. The pilot should not be strapped in too tightly or supported with metal back plates which would prevent elasticity. Although rapid rotation does not occur, rotation at a rate of 90 turn per minute can be tolerated for 60 seconds.

3.112 Experiments in a high speed wind tunnel at the Luftfahrtforschungsanstalt Herman Göring by Ruff and Knackstedt and their associates with the subjects in a catapult seat from the He 280 demonstrated clearly that sudden wind speeds up to a velocity of approximately 510 mph can be withstood momentarily (5 sec. max.) by the head and face without damage provided the mouth is kept firmly closed to avoid pulmonary damage. Once the head is turned at speeds in excess of 150 mph it is practically impossible to return to the normal position. The pressure on the thorax and abdomen is tolerated easily. Respiration is possible up to approximately 300 mph. The German oxygen mask is lifted off the face when looking to one side at an average air speed of 230 mph., and the German goggles are considered unsafe at speeds in excess of 360 mph. The use of a support behind the head double or triple the width of the head alters the air stream and decreases the fluttering of the cheeks and makes respiration easier.

3.113 In flight tests of the catapult seat used in the Do 335 ten subjects ranging in age from 21 to

34 years and in weight from 144 to 169 pounds volunteered for the experiment on the ground. Twenty seven tests were carried out with air pressures of 60 to 135 atmospheres. One subject injured his elbow on his second test with an air pressure of 110 atmospheres and a height above the plane of 6.6 meters. He was excluded from further experiments. Another subject was excluded because of fear after an ejection with a pressure of 115 atmospheres and a height attained of 6.6 m. Nearly all the subjects felt strong pressure on their elbows or forearms from the weight bearing on the padded arm supports. The maximal acceleration was 26 to 28 G for a very short time with an average of 20 to 22 G for most of the time the G was experienced.

Next, experiments were made with the type of seat used in the He 219 which has a shorter stroke of the piston and has no arm supports. Fourteen ejections were carried out with 5 subjects with pressures of 60, 90 and 105 atmospheres. One subject didn't do the experiment with 105 atmospheres. The acceleration was less than with the Do 335 arrangement. One subject had no distress, two felt a sharp blow in the neck with 105 atm; the fourth subject had pains in the thorax and on breathing during and after the ejections with 90 atmospheres so didn't participate in further experiments. The fifth subject during the launching with 105 atm. had a marked sharp pain in the lower thoracic region and shortness of breath followed by cyanosis. The above episode lasted 40 to 50 sec. then he began to breath slowly and returned to normal in about 3 minutes. Because of the arm rest support which relieves about 20% of the weight on the spine a higher G was more easily tolerated with the Do 335 arrangement than with the He 219 unit.

3.114 The formula used by engineers in the Swedish Air Force for calculating the parabola of throw follows: The y axis is considered parellel to the direction of flow and the x axis at right angles pointing backwards. The origin is the center of gravity of the pilot and the seat at the point where the seat slide off the inner tubes. The direction of the force of gravity is above the negative y axis and the direction of thrust is along the positive x axis.

v = true airspeed

v_s = terminal velocity in free fall of the pilot and seat at the actual altitude.

m = mass of pilot and seat

G = weight of pilot and seat

$g = 9.81\ m/sec^2$

V_o = initial velocity of pilot and seat leaving the airplane

x', y', x'', y'' = derivative of x and y against time t.

$$my'' = -G$$

$$mx'' = G\left(\frac{V}{V_s}\right)^2$$

$$y'' = -gt + V_o$$

$$x'' = g\left(\frac{V}{V_s}\right)^2.t$$

$$y' = g\frac{t^2}{2} + V_o t$$

$$x' = g\left(\frac{V}{V_s}\right)^2.\frac{t^2}{2} \text{ elimenate } t$$

$$y' = -\left(\frac{V}{V}s\right).x + V_o\left(\frac{V}{V}s\sqrt{\frac{2x}{2g}}\right.$$

At 750 km/hr around 50 kgs/cm^2 would be needed for a height of 6 m.

3.115 In the design and construction of seats many closely interrelated factors must be taken into account, since successful clearance of the aircraft depends on the speed, attitude and altitude of the aircraft; the depth of the cockpit, distance from the cockpit to the tail and the height of the rudder. Among the factors to be considered are:

- Size of the cockpit and its exit
- Strength of the seat
- Supports on the seat for the feet, hands, arms and head.
- Safety harness adjustment of the seat.
- Aerodynamic clearacteristics of the seat with the man in it.
- Angle of ejection
- Type of release for the conopy and the seat - one between the legs is preferable.
- Type of parachute.
- Ejection method - spring, air, powder or rocket.

3.116 Other methods of escape from high speed fighter aircraft include: catapult ejection downward through a floor hatch, explosive ejection of the entire cockpit; and use of a lever on top of the aircraft connected to the seat over a support which would carry the seat along an arc in the plane of the vertical axis and releasing the seat in the highest position.

3.117 The dangers in using an ejection seat are: injury to arms or legs through improper position, fracture of the vertebrae through not having the shoulder harness fastened and pulmonary injury as the result of not having the mouth firmly closed. The advantage of being able safely to escape from a high speed fighter or medium

bomber far outweigh any potential dangers. Proper indoctrination should minimize accidents.

3.118 Ejection seats and their tracks were removed from the He 162, the Do 335 and the Swedish J-21, and were forwarded through channels.

3.119 References:

"Schleudersitzabschüsse mit Menschen zur Feststellung der Ertäglichkeit der Abschussbeschleunigung bei den Anlagen für die Flugzeugmuster Do 335 and He 219". Wiesehöfer Oct 31, 1944.

"Flugmedizinische Grundlagen zum Bau von Schleudersitzen", Wiesehöfer Oct 27, 1943.

"Untersuchungen zum Sitzkatapult in Technische Berichte" Band 8, 1943.

"Untersuchungen über den Einfluss hoher Windgeschwindigksiten aufden Kopf. U. Schütze" Nov 10, 1940.

"Untersuchungen über den Einfluss plötzlich auftreffender hoher Windgeschwindigkeiten auf den ungeschutzden menschlichen Kopf." Thaler. Sept 10, 1943.

"Gedanken über Entwicklung eines Flugzeuges zum Einsatz in extrem grossen Flughöhen" von Felix Kracht. Nov. 2, 1944.

"Funktionsprüfung und Flugerprobung der Pressluft - Sitzkatapultanlage der He 219". Delenge Feb. 12, 1944.

"Dornier Werke - Versuchsabteilung Katapultzitzeanlage Do 335 Versuchsbericht Nr. 3240". June 23, 1944.

3.12 Parachute Escape

3.121 Introduction. The acceleration magnitudes which can be tolerated by the human body depend upon the following: 1) the direction of acceleration in relation to the axes of the human body; 2) the position of the human body; and 3) the duration of the acceleration. These factors and their importance in the design of equipment are discussed in the following:

1) "Grundriss der Luftfahrtmedizin" 1944 edition by S. Ruff and H. Strughold.

2) "Flugmedizinische Grundlagen zum Bau von Schleudersitzen," 27 October 1943 by Wieschöfer. (Military Publication)

3) "Untersuchungen uber die Verträglichkeit stossförmiger Beschleunigungen," December 1944, by U. Henschke & W. Keidel.

3.122 Occurrence of acceleration during parachute opening, factors influencing the magnitude and methods to minimize these accelerations.

3.123 Opening shock measurements on parachute escapes with dummies are typically greater than human parachute escapes under indentical conditions; likewise a human escape, when the body is stiffened and rigid elicits a greater opening schock than the body which is limp and relaxed. The difference between the peak accelerations may be as much as 100%. The explanation may be made along the lines of the elasticity of the relaxed human body which acts to spread out, in time, the application of the total body weight to the parachute. (These findings do not entirely agree with those of the A.A.F.)

3.124 Physiologically dangerous opening shocks occur at extremely high altitudes (American AAF investigations) and during high velocity escapes. Normal opening shocks of 8-12 "g" may also be dangerous if the orientation of the body is such that radial acceleration results upon opening of the parachute; such acceleration may well result in spinal injury.

3.125 Since the human tolerance of acceleration is greatest when the force acts in the direction head to foot, but is limited even here to 20 "g" for a duration of 0.1 seconds, it is necessary to design a develop parachutes which have the following characteristics: a) A small parachute which serves to orient the body in a vertical position and to decrease the speed of descent before the main chute opens; b) a parachute which has ideal opening characteristics and consequently a minimal opening shock; c) Properly designed parachute harness which applies the opening force near the center of gravity of the body and simultaneously distributes this force over as large an area as possible.

Design and development of parachutes with these characteristics has inpart been undertaken by personnel of the Forschungsanstalt, Graf Zeppelin describ-

ed elsewhere in this report.

3.13 Accelerations Occurring During Flight.

Accelerative forces which interfere with normal human functions and which may be injurious to the human body occur during banking, diving, climbing and other acrobatic manouvers of high speed aircraft, rocket assisted take-offs, parachute braking action, ramming of other aircraft in the air and crash landings.

3.131 To minimize the effects of accelerations encountered during flight the pilot and other crew members should be oriented in a position parellel to the horizontal axis of the aircraft. This may be accomplished by a reclining seat or by horizontal orientation of the pilot. A practical reclining seat is described in the following references:

a) "Über Flugversuche zur Frage der Erträglichkeit hoher Deschleunigunger bei liegender unterbrigung der Flugzenginsassen." 12 July 1939 by Dr. Wiesehöfer.

b) "Sitzanlage mit steuerungseinrichten für hohe Flugbeschleunigungen." Such orientation of the pilot and aircrew increases the tolerance of positive acceleration up to 15 "g" for periods as long as 2 to 3 minutes. This removes the present human g limitation from design of aircraft.

3.132 Accelerations resulting from ramming of other aircraft in the air may be quite high but of short duration (0.01 to 0.02 seconds). Experiments on tolerance of short but high acceleration in relation to body position (see Henschke & Keidel ref. above) indicate that 80 "g" may be tolerated if part of the force is taken up by a movement of the body resulting from the force acting in the direction head - foot. Such movement of the body is possible if subject is lying on his back and permits knees to buckle.

3.133 Accelerations which result from crash landings are great and of short duration but are not necessarily injurious to the pilot and aircrew if they are properly protected. For example the high accelerations occuring during catapult launching of aircraft are not injurious because the force is distributed over a large area. Since the acceleration resulting from crash landings exert forces in the opposite directions, it is necessary to design crash harnesses which will distribute the force over the greatest possible area and over those parts of the body

that can not be readily injured. Experimental measurements indicate that forces of 1700 Kg. can be safely tolerated. Such experiments on crash harness design are described in a previous reference (Ruff and Strughold) and in an article.

"Uber die Entstehungsursache schwerer innerer Verletzung bei Insassen von Cleitflugzeugen infolge hoher Verzögerungen bei Bruchlandungen und über Massnahmen zur Verneidung dieser Verletzung." 16 Dec 1938 Dr. Siegfried Ruff.

3.2 Physiological Reactions at extreme altitudes.

3.21 Survival times at extremely high altitudes.

With the design and development of pressurized cabin aircraft capable of flying at extreme altitudes the problem of human physiology at these extremely low pressure environments must be considered. Emergencies will arise when the cabin pressure is lost and aircrew will be subjected to the fatally low barometric pressure. To determine the simplest and most affective emergency procedure the time reserves at different altitudes were determined. They are:

Altitude		Time Reserve (Pure Oxygen)
(46,000 ft.)	14 km.	50 sec.
(47,000 ft.)	14.5 km.	25 sec.
(49,000 ft.)	15 km.	15 sec.
(51,000 ft.)	15.5 km.	10 sec.
(52,500 ft.)	16 km.	9 sec.
(55,800 ft.)	17 km.	9 sec.

These data were taken from the article "Über Rettungsmöglichkeiten beim Flug in grossen Höhen" by Siegfried Ruff.

Aircraft flying at altitudes where the time reserve is 10 seconds or longer were to have an automatic diving mechanism which would bring the aircraft swiftly down again and back into level flight at a safe altitude. Such a mechanism is useless at altitudes above 50,000 ft. and other emergency measures are indicated: a) Parachute escape and free fall until consciousness is regained. If altitude is 20 km (65,600 ft) unconsciousness will occur at 19.75 km (with or without oxygen) and consciousness will occur at 10.55 km (35,500 ft) if oxygen had been used and 4.2 km (14,000 ft) if oxygen had not been used. b) Use of a light weight pressure suit which inflates automatically upon loss of pressure. Such a suit was being developed by the Draegerwerke, Lübeck.

3.22 The effect of severe anoxia at various altitudes.

During investigation of emergency procedures at extreme altitudes it was discovered that in animals recovery from severe anoxia was possible at altitudes above 65,000 feet, whereas severe anoxia at lower altitudes usually resulted in death. This phenomenon was attributed to a severe atalectasis caused by boiling of the blood, which causes distention of the capillary bed and blood vessels, occluding the lumen of the lungs and completely shutting off air exchange and circulation. This prevents the blood from losing what little oxygen it has and maintains life in the body tissues during the exposure. During descent this atalectasis is relieved and if pure oxygen is breathed recovery takes place. For further details refer to the articles listed under the discussion of the Aeromedical Research Laboratory, Freising.

3.3 The relation of physiological reaction time to speed of modern aircraft.

The actions of a pilot or aircrew member are the result of a complex stimulus - response mechanism in which there is an inherent time loss. This time lost is the total time required for the various organs to perform their individual functions. Since the stimulus - response mechanism consists of a series of reactions, the individual latent periods and reaction times are additive and the total time required between the beginning of stimulus and the beginning of response may be called the physiological reaction time. This time becomes extremely significant in view of high speed aircraft; for example: the average reaction time is 0.2 seconds. During this time a plane traveling at 500 mph will have covered about 150 ft. the occurance of any obstacle in this distance will be fatal, for the pilot is powerless to react.

3.4 The effect physiologically of blasts and vibrations.

The investigation of the cause of death from detonation has been rather thoroughly done by German investigators and for details refer to the section dealing with the Aeromedical Laboratory, Brannenberg and the section on Forschungsanstalt Graf Zeppelin. Detonation death is most likely the result of lung injury and the extensive occurrence of air emboli in the blood vessels.

3.42 The physiological ill-effects of low frequency (about 50 cycles per second) but high energy sound waves, such as are produced by the intermittent jet engine (V-1 power unit) may be related to the physiological effect of blast. It is certainly indicated that this province be further investigated.

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3.43 The mechanical vibration on various parts of the human body elicit symptoms similar to those produced by sound waves but are localized and not so severe. The analogies are enough to stimulate further investigation into this field as well as the effect of high energy supersonic vibration, which occur in all high speed aircraft. For further details on this subject refer to section on Reichsanstalt für Hochfrequenzforschung, Helmholz institute.

CONCLUSIONS:

1. This investigation into the activity of institutions and personnel in the realm of aviation physiology, medicine and "human engineering" has indicated that important and interesting work has been accomplished on the following subjects:

1.1 Pilot ejection

1.2 Emergency procedures for escape from pressurized cabins at high altitude.

1.3 Effect of high wind velocities on the human head, thorax and abdomen.

1.4 The liaison approach between aircrew and machine being operated, to improve efficiency of operation.

1.5 Research and development of personnel parachute.

Vernon J. Wulff, 1st Lt., A.C.
W. Randolph Lovelace, Col., M.C.

APPENDIX I

TEMPORARY DUTY ORDERS

HEADQUARTERS
ARMY AIR FORCES
AIR TECHNICAL SERVICE COMMAND
WRIGHT FIELD, DAYTON, OHIO

A202

ICE

SUBJECT: Letter Orders No. A5-2-15. 2 May 1945

TO : Col William R Lovelace, II 0337848 MC
Lt Col Thorelph J Tobiassen 0214698 AC
Maj Arnold D Dircksen 0246428 AC
Maj Lewis T Gasink 0410815 AC
Maj Russell M Houghton 0317475 AC
Capt Ernest C Simpson 0374738 AC
Capt Charles F Sopeak 0393078 AC
1st Lt Vernor J Wulff 0579733 AC
ATSC, 4020th AAF Base Unit (Hq. ATSC)
Wright Field, Dayton, Ohio.

1. Pursuant to Restricted ltr. CG of AAF, File AFPMF-4 210.453, Subj: "Temporary Duty Orders", 27 Apr 45, you are atchd to Shipment AK-B628-AA and dir to proceed at the proper time from your present sta to Cravelly Point, Va, reporting not later than 5 May 1945 to Embarkation Off, Washington, PE, Rm 1742 for TDY pending movement overseas under APR-UST-3-10174-AAF-Apr for TDY approximately 90 days, reporting CG of AAF for dy with Directorate of Intelligence, purpose in connection with post hostilities intelligence matters, and upon compl of dy ret to proper sta.

2. Tvl by commercial acft (Par 3, AR 55-120, 26 Apr 1943), mil or naval acft or any other available means of transportation from Wright Field, Dayton, Ohio to destination and ret is dir and is necessary for the accomplishment of emerg war mission. WD Cir 260, 1944 will apply in the continental limits of the US. Sec 2, WD Cir 356, 1944 will apply outside the continental limits of the US.

3. Provisions of POR, 15 May 1944, regarding immunizations will be complied with immediately. You will be equipped at Gravelly Point, Va for temperate climate.

4. Just prior to departure, you are advised to notify correspondents by use of WD AGO Form 204 (Change of

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Address Card) that mail will be addressed to you at APO 19384, in care of Postmaster, New York, NY; also send Form 923 (Notice to Publishers).

5. You are designated of l courier for purpose of transporting ofl documents. Each package or envelope containing ofl matter to be exempted from examination will bear on exterior cover inscription "Official United States Army Communication Exempted from Censorship" followed by signature of ofl title of competent auth disptaching the documents by special courier. You will obtain letter describing communications to be exempted from examination by customs.

6. CIPAP. TDN. 501-22 P 432-03, 03, 212/50425.

BY COMMAND OF MAJOR GENERAL MEYERS:

ROY W SMITH
Lt Col AGD
Asst AG

DISTRIBUTION:
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1 - CGofAAF (Attn: Management Control, 201 File)
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1 - TSPMP1b
1 - TSPER1c
1 - TSENG
1 - TSAGO2A
1 - TSAGO2B

I certify that this is a true copy:

WILLIAM P. SHEELEY
Major, Medical Corps.

APPENDIX I
Cont'd

TSENG (TSEAL-3D) VJW:mhk:TSEAL-3D

Purpose of Mission.

To Whom it may Concern.

1. Reference is made Air Technical Service Command letter dated 30 April 1945, subject: Instructions of Duty in E.T.O., which reads as follows:

"1. In compliance with AAF Letter 35-78, dated 13 April 1944, subject, "Issuance of Instructions," the following instructions are furnished in connection with your mission to the European Theater of Operations.

2. You will gather information on Enemy Equipment and Facilities for the purpose of future study and eveluation".

2. The purpose of this mission in compliance with Letter Order No. A5-2-15, dated 2 May 1945, shall be to investigate those elements of German research, engineering design, development and manufactured commodities which will be of value in furthering research, engineering design, development and manufacture of aircraft equipment of an aero-medical nature, as follows:

a. Pilot ejection from high speed rocket and jet propelled aircraft.

b. Equipment for measuring and diminishing the forces existing during parachute openings.

c. Equipment for protection of aviators from the deleterious effects of rapid acceleration and deceleration.

d. Equipment used to investigate the physiological aspects of low temperature environments and the effciency of protective garments.

d.1 To visit the physiological laboratory, RAE, Farnborough, to discuss recent de-

velopments in aviation medicine and aviation physiology.

e. Equipment for the relief of pilot fatigue during long range missions.

f. Equipment for the protection of eyes.

g. Equipment for the evacuation of the sick and wounded by air.

h. Equipment for the production disposal and dispensing of liquid and gaseous oxygen for use on the ground and in aircraft, as a source of breathing oxygen or as a source of fuel for rockets.

i. Generators for the production of carbon dioxide.

j. Equipment used to investigate the physiologic aspects of low pressure environments.

k. Carbon dioxide inflation gear for life rafts and life vests.

l. Portable water purification units.

For the Acting Director:

F. O. CARROLL,
Brig. General, U.S.A.
Chief, Engineering Division.

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APPENDIX II

REPORT OF INFORMATION OBTAINED DURING 5/16/45 to 5/23/45

FROM INTERVIEW WITH Dr. Ing. F. HOLLMANN

- - - - - - - - - - - - - - -

1. Parachute emergency oxygen apparatus.

a. Description.

This apparatus consists of a series of high pressure cylinders which are arranged in a parallel manner to form a flat plate, about an inch thick. The diameter of the cylinder is about 3/4 of one inch. The cylinders are connected to an outlet valve through a narrow tube, which is about 1 m long and which acts as a metering orifice. The entire assembly is flat and fits into a pocket in both the seat and backtype parachutes. During normal flight this emergency system is connected to the main aircraft oxygen system. A ripcord attaches the parachute assembly to the aircraft seat and when the pilot wishes to leave the airplace, that portion of the emergency system which is attached to the main oxygen system is detached and the emergency oxygen flow valve is opened.

b. Operating characteristics.

The emergency oxygen system is charged to 150 atm pressure and has sufficient capacity to last about 20 min. Theoretical and experimental flow data are in agreement. Experiments conducted with small and shorter orifices indicated freezing because of the adiatatic expansions of the oxygen. The long narrow tube was the solution. For further details refer to Research Reports.

c. Future developments.

The arrangement of the cylinders in a manner to leave a hole in the center for the pilots has been considered to give greater comfort. No other changes were indicated.

d. Samples for study.

Arrangements have been made to have several samples sent to interested agencies for test and study purposes.

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c. Comments.

This apparatus is unique in the German Air Forces and is of considerable interest to the U.S.A.A.F. The incorporation of the oxygen apparatus with the parachute is a good idea and merits further development. The existence of this apparatus has been known for a long time but these are the first models which have been obtained. The design engineer and the manufacturer have been extremely cooperative in discussing this device.

2. High Altitude Demand Regulators.

a. Description.

The Dragerwerke have lately constructed demand regulators only for pursuit aircraft having a high rate of climb and high altitude performance. This resulted in a regulator without the air diluting mechanism and with an aneroid capsule attached to the diaphram to deliver about 15 mm H_2O col. positive pressure above 10 km altitude. The structural details may be seen in documents listed elsewhere in this report and pertaining to the "Umsteuerhohenatmer." With the loss of the productive capacity of the Auer-Gesellschaft in Berlin, the Dragerwerke built the above regulator with a diluter mechanism.

b. Operating Characteristics.

The functional characteristics are described in detail elsewhere (refer to the list of documents). The opening suction of the regulator is about 10 mm H_2O column pressure and the positive pressure of 15 mm H_2O col. pressure sets in at 10 km. Production regulators were tested for opening pressure, pressure required to obtain flows of certain values, the volume of flow obtained by manual depression of the diaphragms, the adjustment of the aneroid, etc. In addition, the check valves, oxygen indicator and pressure gages were tested for accuracy, calibration and leak tightness. For further details of this test set-up refer to drawings and descriptions listed in this report.

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c. Research Results.

Considerable research has been carried out on this high altitude regulator, the most important and greater part of the research were carried out here. The research and design of the original regulators was based on the original data from Barcroft, Haldane, etc. and the design was not particularly based on research carried out by German agencies. For details of research on this regulator refer to the included list of documents attached to this report.

d. Equipment.

The regulator has been studied by some allied agencies. Additional models are being evacuated however, to supplement those already existing. Several samples of the aneroid are being evacuated for further study in the automatic loading of diaphragms of demand valves.

e. Comment.

The regulators for use in the G.A.F. have all been designed and most of them built by the Dragerwerke. The performance has, in general been satisfactory. The engineer and other members of the firm were very cooperative.

3. Combination Oxygen Indicator and Pressure Gage.

a. Description.

This is a device which indicates to the user the pressure of the gaseous oxygen (and therefore the supply) in the cylinders as well as giving a signal at every breathing cycle of the person-regulator combination. Theoretically, non-function of the blinker indicates non-function of the regulator. The blinker is actuated by pressure acting on a diaphragm, which is coupled to two bands, visible from the front of the instruments and which are phosphorescent, which move out of view behind two plates. The mechanism is quite simple.

b. Operating Characteristics.

The operation of the blinker is not affected by vibration and by cold of -45° C only to the extent that the leaves close more slowly. The pressure gage is calibrated at the bottom and top of the range and reads in fractions of supply rather than pressure.

c. Research Results.

The combination indicator emanated out of the idea to consolidate the pressure gage and blinker into one housing. No extensive research was conducted.

d. Equipment.

Several samples of this instrument have been evacuated for further study in connection with the central warning panel.

4. Regulator Test Instruments.

a. Description.

(1) Universal test instruments. This is a rotary scale instrument for the measurement of flow, positive and negative pressures to test any type of oxygen dispensing mechanism. For further details refer to the references listed in this report.

(2) Oxygen purity analyzer. This is a manometric type analyzer using a solution of 50% NH_4OH solution and an equal volume of saturated $(NH_4)_2CO_3$ solution for absorbing the oxygen. The quantity of oxygen absorbed is indicated on the volumetric tube.

(3) Demand regulator leak tester. A device for measuring leakage in a demand regulator installed in the plane. This device measures the positive pressure upon leakage from the demand valve, and negative pressure drop to test for leakage at the diaphragm, etc.

b. The operating characteristics are adequately described in reference listed in this report.

c. Research Results.

The research on these instruments was only that connected with their design.

d. Equipment.

Several models of each item of equipment have been evacuated except the regulator leak tester, of which none were available.

e. Comments.

These testing devices are all visual. The O_2-purity analyzer requires about 5 min for one analysis and the

solution deteriorates quite rapidly. The Scholander device used by Allied agencies is believed to be just as accurate and superior in other respects. The other devices are indicating mechanical devices which are practical for field use.

5. Reducing Regulators.

a. Introduction.

Reducing regulators have played a very important part in industry and the armed forces of Germany. The government agencies which were interested in producing equipment such as the V1, V2, and submarine devices, often assumed that reducing regulators were readily obtained and therefore came to the Dragerwerke very late to obtain the proper regulator, only to learn that it had to be designed and developed. It was also learned that information as to the use of the regulator was not divulged to the engineer, except that which was absolutely necessary for the design. This resulted occasionally in the delivery of the wrong reducing valve. These procedures caused a considerable delay in the appearance of the V2.

b. Description.

Reducing regulators have been designed and built by this firm for a variety of purposes, which are listed below:

(1) Katapult Seat.

Early trial with pilot ejection used a blast of compressed air, acting on a piston attached to the seat, to eject seat and pilot. Since ejection must be very rapid, a high capacity pressure reducing regulator was required. Such a regulator was designed and built, including a modification by which the regulator could be turned on by an explosive charge.

(2) High Pressure Reducing Regulators.

Economy of space and time have led to use of very high pressure gases (400 atm). For these very high pressure reducing valves have been designed and built.

(3) Automatic compensating regulators for divers and torpedo tubes.

Reducing regulators have been built for use on diving suits and submarines whose outlet flow and pressure is controlled by the water pressure. This prevents accidents

in case of a sudden increase in depth of either the diver or the submarine. CO_2 gas was used to keep the torpedo tubes clear of sea water.

(4) Suspended Buoy Reducing Regulators.

Buoys were built by the Germans which would, after a certain period of immersion, generate gas, displace water, and rise near the surface and emit either a characteristic sound or a phosphorescent glare, after which they would sink from view again, thereafter to rise at regular intervals, thus intermittently marking the way.

(5) Reducing Regulators for Underwater Diesel Motor Operation.

A circulatory system has been evolved to supply Diesel Engines with suitable mixtures of oxygen and nitrogen. The exhaust gases are filtered and purified, the noxious gases are dumped to the outside and the useful gases are recirculated through the system. The reducing regulators for this system were designed and built by the Dragerwerke.

(6) Regulators for Shallow Swimming and Diving Suits.

A complete rubber diving suit for bridge repair and construction had been built by an Italian company, copied and improved by the Dragerwerke. This suit is equipped with web like hands and feet for easy swimming. When the head is above the water level air is breathed and when the head is below water oxygen is permitted to flow into a reservoir by a manual operation of the reducing regulator. These suits were service tested for repair of the Nijmegen Bridge and worked quite satisfactorily, although there is some objection to these suits by personnel using them.

(7) Regulator for ejection of torpedoes.

A high capacity pressure reducing regulator has been developed for the ejection of torpedoes in submarines. These regulators have an extremely high capacity and only a few experimental models have been built.

(8) Protective devices against explosions occurring in the lines of oxy-acetylene torches.

This is a fitting containing a check valve and an unglazed ceramic disc. The check valve prevents any

back flow into either tank and the ceramic disc conducts heat away so that explosive temperatures cannot be reached. A check valve is not sufficient, because the explosion travels faster than the pressure wave which closes the valve. Other materials have been tried for heat conduction, i.e. glass wool, metals, etc., but unglazed ceramic has been found most satisfactory. When leakage from one line into another exists for a long time the ceramic may heat up. Hence, it is necessary to close the regulators before this happens, which indicates an awareness of the situation.

(9) These items described above are only in part available, but drawings exist on all and have been requested. The engineer was cooperative in divulging information only after he had been told to hide nothing from the investigating team.

6. Pressure Suits.

Investigation on pressure suits for use at high altitudes by aircrew has been intermittently underway since 1930. The development has been an interesting one but its ultimate use in aircraft is not considered practical, since motion and sense of touch is restricted to the extent that piloting of an aircraft is distinctly problematical. Development of this item was nevertheless stimulated by officials of the G.A.F. The development along this line was principally one of improving the leak tightness and flexibility of the joints.

a. Description.

The latest suit, of which only one incomplete item is available, is made of rubberized fabric with ball bearing joints that may be of some interest to allied agencies. The helmet is a plastic device reinforced with metallic bands. The oxygen mask used has inlet and outlet tubes and is attached to the demand regulator which is subjected to the pressure environment within the suit. The suit is equipped with two safety valves, the primary one of which has excellent flor characteristics.

b. Operating characteristics.

The suit may either be inflated by compressed air or oxygen and ventilation is achieved only when the relief valve has opened. Oxygen for breathing is obtained through a mask from a demand regulator which is subjected to the pressure in the suit.

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c. Research Results.

Research at this factory has confined itself to those aspects necessary for development. Several altitudes trials have been made and these are reported in detail in research reports listed among the documents.

d. Comments.

Development of this item has not progressed as far as had been hoped. However, consideration of the ball bearing joint may be of some value to allied agencies.

7. Anesthesia and Inhalation Apparatus.

a. Introduction.

The majority of this apparatus was designed and built before the war and hence no striking developments exist. Since in German medicine anesthetists are not specially trained for their job, the machines have to be fool-proof. The three developments which deserve mention are: 1. The use of heated plate for vaporization of the ether, to raise the temperature of the gas mixture at the mask. This decreases the chances of ill effects on the respiratory tract and decreases the severity of the after effects of narcosis. The plate is kept at a constant temperature of 60° C by an electrical heater. 2. The use of an aspirator to introduce liquid medicaments into the narcotic gas mixture. 3. The use of a water check valve and a filter on the exhalation side of the circuit to give an indication of breathing and take out the ether not utilized. This prevents the accumulation of ether in the operating room. Another development is the use of conductive rubber on the wheels and tubes of anesthesia apparatus to prevent the accumulation of static electricity. Electric conductors to ground are also supplied to the machine and the operating table.

b. Description.

The description of the anesthesia and inhalation devices are adequately described in the literature on this subject, of which a list is included in this report.

c. Comments.

The engineer in this department, Eng. Joseph Haupt, worked on a constant flow system for a Ju 52 for evacuation of wounded from Africa. He also developed the douche valve for the swim suit previously described.

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8. Carbon Monoxide Indicatn a. Measuring devices.

The carbon monoxide indicator consists of a double acting suction pump and a capsule containing an absorbing medium for hydrocarbon and a color indicator for CO. To obtain a quantitative indication 10 strokes should be made with the pump and then a color comparison made to determine the quantity.

The carbon monoxide measuring apparatus consists of a differential thermometer consisting of two arms and a common center piece. The lower portion of the two arms are filled with mercury, filled with a fluid (described in literature listed in the index) and sealed by two metallic ends of high thermal conductivity. One of these ends is embedded in a container of hopcalite, which acts as a catalyst for oxidation of CO_2. This process generates heat which is measured by the differential thermometer. The other heat contact is embedded in a substance having a heat conductivity similar to the hopcalite. The instrument has a lag of 5 to 7 minutes with increasing CO concentrations and 10 min. with decreasing concentration. The instrument will indicate CO concentrations of the magnitude of 0.025 by volume. The limit of the scale is 0.2%. Use of this instrument at lower than atmospheric pressures will probably necessitate recalibration. This instrument is well designed and built and has a wide application. It merits further investigation.

Developments of Dr.Ing.F. Hollmann.

A. Development of high altitude safety pressure demand regulators. Several methods have been developed and some of them tried, to produce a slight positive pressure to reduce the effects of mask leakage at altitude. These methods are all designed to supply an additional force to the oxygen inlet valve, to open the valve slightly and permit a positive pressure in the regulator. The mechanism has been designed to produce a positive pressure between 10 and 15 mm H_2O column.

(a) Constant Safety Pressure.

This mechanism is activiated by blinker line pressure, which pressure builds up between 1 and 3 atm. only during inspiration. The pressure is conducted to a small diaphragm which actuates a rod connected to the inlet valve, which opens slightly, producing a flow of O_2 under a slight positive pressure. A small bleed orifice is provided to permit lose of pressure during expiration. The drawings and patent claims for this system are included in the list of documents.

(b) Solenoid.

To accomplish the same act a device using an electric solenoid was designed but not tried. The solenoid is actuated electrically and opens the inlet valve. This method is obviously more complex.

(c) A third method was tried to accomplish the foregoing by means of an aneroid, so that the safety pressure would be applied in relation to altitude. This requires the aneroid system, exposed to ambient pressures, and the system for opening the main oxygen inlet valve. This method combined with the method described in (a) suggests a scheme for producing a continuous safety pressure and a positive pressure which increases with altitude.

(d) A fourth method wa s presented, utilizing the positive expiratory pressure to aid in depressing the diaphragm, thus aiding the following inspiratory effort. This method has been tested and works but is susceptible to freezing. Diagrams illustrating this and the foregoing principles are included in the list of documents attached to this report.

B. Liquid Oxygen Vaporizer for use in aircraft.

The engineers at Dragerwerke began to experiment with liquid oxygen installations for long range aircraft in 1943. They built one experimental converter with atmospheric heat exchanger and rapid pressure build up similar to the schemes now in use by the allied. Schematic drawings of the system and a detailed diagram of the control valve system have been obtained. The above named engineer expressed the opinion that the use of liquid oxygen installations was practical only for long range aircraft.

C. Pressure Equalizer for demand Regulators.

To maintain a constant opening pressure and resistance to inhalation with dropping pressure in the supply system a mechanism is incorporated which tends to equalize the forces on the oxygen valve. The methods for accomplishing this are variable but all embody the principle of the force of a spring counteracting the force of the pressure exerted on a known area. A new scheme for doing this has been developed and the patent claim drawings have been obtained.

D. Automix Valve Opening Scheme.

To insure against a high percentage air or all air inspiration in shallow breathing it is necessary that the

automatix valve be opened by operation of the injector. To accomplish this a pressure line has been connected from the blinker line to the valve opening mechanism in the automix box. Patent claim diagrams have been obtained.

E. Goggles for Spray Painters.

To prevent the accumulation of paint on goggles a flow of compressed air is emitted from the upper and lower rim of the goggles. The air stream prevents the accumulation of paint on the goggles.

F. Demand Operated Reducing Valve.

A small reducing regulator has been designed which is actuated by small negative pressure. No model of this device has been built and many engineering problems will probably present themselves upon construction.

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APPENDIX III

Report by Colonel W. R. Lovelace, CIOS. 25 May 1945
Lt. W. J. Wulff, CIOS.

LOCATION: Luftfahrtforschunganstalt (CIOS) Target No. 25/71

SUBJECT : Interrogation report concerning studies on effect of high wind velocities on human subjects.

NAMES : Prof.Dr.Ing.Adolf Buseman-Prof.Dr.Ing.Wilhelm Knackstedt

INTERVIEWERS: Colonel Lovelance and Lt. Wulff.

1. To the knowledge of these two men, no work had been carried out at the L.F.A. on human parachute shock, ejection of pilots from high speed aircraft, or on the design of the ejector seat, or on pressure cabins and related controls.

2. One series of experiments were conducted on six (6) human subjects who were introduced into constant wind stream of 560 Km/h (ground level) velocity for periods of between 3 and 5 seconds. The subject controlled his own exposure and could be automatically removed from the windstream by the release of a grip handle.

3. Tests were also conducted on a wooden head, with pressure measurements. The pressure taps were made in the forehead, eyes, nose, skin and throat, and recorded in the report from the L.F.A. No. 32, title "Untersuchungen am Menschlichen Korper bei Hohen Standrucken", which is being processed.

4. No deleterious effects were experienced by any of these subjects. For further details see the above mentioned reports.

Experiments tried with oxygen mask on face -- mask was pulled off face. It was indicated that full face mask and goggle assembly be built whose total area is not appreciably greater than the area of the face. All experiments were tried with subjects facing into the windstream. This was assumed to be the position of the person ejected into the wind stream but may not necessarily be so.

The effect of the acceleration of the aircraft on performance of the catapult seat is not known.

APPENDIX IV

ABSTRACT

Untersuchungen Über den Einfluss hoher Windgeschwindigkeiten suf den Kopf by U. Schutze.
Investigation of the Effect of High wind Velocities on the Head. 1940. (Deutsche Luft Fehrtforschung).

1. With unprotected head, ram pressures up to 1130 Kg/m^2 resulting from 500 Km/h velocity can be sustained (one collapse occurred in this series -- due possibly to pressure on carotid sinus, pain, fear, other causes). Breathing is possible but irregular and shallow.

2. Examination of goggles revealed that they are not safe at ram pressure of 2,000 Kg/m^2, at speeds of 600 Km/h (Ground level), and constitute a danger to the eyes. The rubber strap breaks at oblique flows of 250 Km/h and the goggles fly off.

3. Investigation with head boards two to three times as wide as the head placed just behind the head creates a back pressure because of turbulence which partially offsets the ram pressure. This effect increases with increasing board width from 1 x head width to 2 or 3 x head width (refer to table pp. 19. this report).

ABSTRACT

Untersuchungen über den Einfluss suftreffender hoher Windgeschwindigkeiten auf den ungischützten menschichen Kopf, bei Thaler.
Investigations on the influence of high wind velocities on the unprotected human head. Deutsche Luftfahrtforschung. 10 September 1943.

1. Trials in a wind tunnel with constant wind velocities on the unprotected head indicated that velocities up to 850 km/h (ground level) can be sustained. The rapid onset of high wind velocities can, however, catch one off guard, so that high ram pressures may be exerted on the respiratory system. Injury to other organs is not indicated.

ABSTRACT

Über Beschleunig-ungsuntusuchungen am Menschen - S. Ruff.
Concerning acceleration experiments on Man. 1941. D.L.F.

1. Measurement of systolic and disstolic pressure every 15 seconds indicated that acceleration of 3 "g" can be sustained for long periods without difficulty. Above 3 "g" visual and mental disturbances began. The pulse rate increase rapidly in all trials.

2. "G" tolerance increases during digestive processes and with addition of CO_2 to breathed mixtures.

3. Use of abdominal bands did not increase "g" tolerance.

4. To sustain "g" higher than 3, it is necessary to place aircrew in horizontal positions.

5. Systolic and Diastolic blood pressure measurements were made with the wrist cuff method, blown up to 200 mm Hg and bleeding pressure down while recording cuff pressure and pulsations. This method is worth while investigating.

Medical Research Institute at Garmisch-Partenkirchen

Results of Interrogation of Dr. Henschke and his co-workers

6/6/45

Subject: Research on Medical Aspects of Aircraft Design and on Development and Application of Prosthetic Appliance.

1. Effect of Acceleration.

It is important to know the mimitations of the human body subjected to "g" forces for various time periods for the following reasons. a) To study crash injuries and methods for protecting against high accelerative forces. b) To develop suitable ejection seats. c) To develop aircraft which ram other aircraft in the air.

Dr. Henschke and his group carried out research on this topic, using a swing which was stopped rapidly at the bottom of the swing by a strong cable. The "g" was recorded with a tensionmeter and the position of the subject in the carriage could be varied. The report has been translated and the "g" was applied for 0.010 records. The max. g varied with position of the subject, but in all cases the limitation was believed to have been 10 g sustained by the brain, for above that acceleration concussion will occur.

2. Sights for Modern Aircraft.

a) Gun sights for moving targets.

Most of gun sights to date consist of several objects which must be lined up with the eye. These objects are at various distances from the eye and it requires about 1/2 second for the eye to accommodate to these distances. This time lag is extremely critical for aiming at moving targets. To avoid this time lag it is essential to have aiming sights which do not require any accommodation. This is possible by placing a hole near the eye and a cross or circle at end of gun.

Magnification for firing of machine guns is desirable only for night fighting, because the visual acuity for the cones and rods varies so greatly. The bullets fired from a

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machine gun have a certain amount of scatter. With cone vision the acuity is great enough to discern hits within this cone of scatter. Additional magnification increases this acuity and renders the visibility of the entire cone of scatter more difficult and therefore decreases the accuracy. With rod vision the acuity is so much worse that hits within the cone of scatter cannot be discerned. Hence, magnification to increase the visual acuity is desirable.

b) Sights for guiding of controlled bombs.

Unless a visual contrast is provided it is extremely difficult to observe the movement of a point in space - i.e. the movement of a guided bomb against the sea or sky. To successfully guide the missile it is necessary to provide a grid on the observation window or on the sight.

Secondly, it is important to perceive small distances of travel because of the acceleration of gravity to which the bomb is subjected makes the control more difficult the longer it moves in a given direction. To remedy this difficulty at least in part it is essential that magnification be provided. The upper limit of magnification is determined by the difficulty in keeping the bomb in view. With a grid and magnification of 4 x the accuracy of hits with a Hs 294 at height of 6 km is 100% (This figure is questionable - WRL)

c) Bomb Sights.

It is essential that a fixed telescope be provided, as in the Norden sight, so that the swaying of the aircraft is not transmitted to the instrument cross hairs.

d) Fighter gun-fire errors.

Gun camera movies and reports indicate that fighter pilots begin firing too soon and stop too early. This is purely psychological and can be remedied only by thorough training.

3. Control of Aircraft.

a) Transmission of Motion

Two types of steering mechanisms are employed, the direct coupled method and the remote controlled method used in our power turrets. The accuracy of aiming by the direct method is much greater in untrained personnel than with the remote method, and it is only with considerable training that the remote method, becomes sufficient, It is Dr. Henschke's

belief that the ideal coupling mechanism is one which employs both direct and remote coupling methods.

b) The design of steering gear.

It is Dr. Henschke's contention that the feet and legs are made for heavy work and that they cannot make adjustments nearly as well as the hands. Aiming devices operated by the hands are 100% more accurate than those operated with the feet. A second advantage of incorporating all steering motions into one hand assembly is that the instictive movements of the body can be used to guide the aircraft. Gun camera pictures and flight reports indicate that the vertical steering of aircraft is very accurate when accompanied by very much weaving, when this steering is accomplished by the feet. Hence, accuracy of steering aircraft may improve by having all controls operated by hand. This principle has yet to be carried to an actual flight test.

A fourth advantage of this hand mechanism is the ability of pilot to bend far forward since the legs may be drawn under the body. This permits head and heart to be on same level and increases tolerance to "g".

c) Design of Handles.

It is important that the type of handle for a particular instrument be properly designed for optional performances of the man-instrument combination. On design of handles the following consideration exist:

1. Height of handle or grip in relation to body.

2. Suitability of arm motions (plane   ) to be used.

3. Effect of vibration of handle.

4. Effect of acceleration on handle.

Experiments have indicated that change in design of a gun handles may increase accuracy by 100%. The design of handles must be undertaken for each instrument separately.

For objective tests on these various devices. Dr. Henschke uses a mercury arc lamp which is focused on a photocell which is on the end of a 3 foot rotating rod. The current from the photocell actuates a light, a counter and a clock, which turns only when the photocell is active.

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4. Vision from Aircraft.

The use of vision aided as well as unaided is principally for: a) Finding of objects in the sky b) Recognition of objects in the sky c) Orientation of the aircraft

a) The unaided eye during the day has sufficient visual acuity and breadth of vision to realise optimal scanning of the sky. Magnification is desirable because it increases the acuity, but undesirable because it decreases the scanning ability. Hence, Dr. Henschke has made various modifications of the binocular to achieve the advantage of magnification and not destroy the scanning ability.

b) Magnification for increased visual acuity for recognition of aircraft is desirable and the upper limit of magnification is limited by vibration and swaying of the aircraft. The conventional binocular was rarely used in aircraft, but various modifications were made by Dr. Henschke to steady the magnifying glasses. These methods are all described in reports evacuated.

5. Prosthetic Aids

a) An aid for the blind.

By means of a balanced oscillator and a tphtocell fed oscillator light intentities are transferred into sound, which enable the blind to distinguish light regions from dark. To increase the acuity of discernment lenses may be applied and a narrow photocell be used. This method, when used in connection with a scanning device, may be used to indentify letters by certain tonal rhythms. By proper training, reading of words and sentences letter by letter is possible.

This research is also just atarted. The electrical circuit still has many flaws in it and the idea needs refinement and sharpening, but the ideas exist and may be readily developed.

b) Actuated prosthetic extremities

Personnel with amputated legs or arms are still able to move the muscle remnants which motivated the extremities now absent. This movement of the muscle results in a muscle action current which, when obtained and amplified, may be used to operate relays which in turn operate solenoids or other actuating devices. Research on this appliance has been completed only to the extent that electrodes and amplifier for obtaining the muscle action current and amplifying it has been developed and one artificial hand

with a solenoid for actuating the closing of the grip constructed.

c) Electronic Geiger Counter

This device results in an audible sound whenever a radioctive molecule is received by the pick up unit. Hence, by the frequency of the sound repetitions the amount of radioactive material present may be determined.

6. Interference of monochromatic light with Vision in the dark

Tests have been conducted to determine the effect of a controlled intensity of monochromatic light falling on a particular area of the retina of dark adapted eyes on the ability to recognize objects with very low intensity light contrast. The intensity of the monochromatic light was controlled subjectively by the ability of the subject to see a fine hair located between the eyes and the source of monochromatic light. The object to be recognized consisted of black circles of varying diameters placed on the periphery of a circular white background, which was rotated. The subject had to locate the position of the black circle.

Tests were conducted in two ways:

1. Illuminating one eye with monochromatic light and searching with the other.

2. Illuminating the same eye with which vision is attempted. Both methods indicate a marked interference of the monochromatic light with rod vision, indicating that it is a central nervous system phenomenon rather than a retinal light adaptation. The results also indicate that the magnitude of the interference varies with the wave length of light, the interference being least with light in the orange part of the spectrum.

7. Improvement of Man's Efficiency by Physical and Chemical Methods.

The use of chemical substances, such as tea, coffee and alcohol have long been used to improve the working ability of man under severe stress or under usual working circumstances. Recently other drugs such as benzedrine have been used to relieve the fatigue encountered during long periods of strenuous but monotonous work, such as piloting aircraft on long combat missions.

The investigation of the effectiveness of certain

chemical substances and of physical stimulation in improving man's ability to work and willingness to work was undertaken to evaluate the drugs and physical stimulation. The drugs tested were: caffeine, pervitin, morphine, alcohol, dilantin and cardiozole. The physical stimulus consisted of the Finnish bath, the Sauna, and treatment with artificial sunlight. It was determined that coffeine is a drug which results in extreme irritability of the nervous system but with a loss of confidence; that a mixture of coffeine and cardiozole gives excellent results; that dilantin depresses the individual; that morphine given rise to the desire to rest and sleep; that benzidrine is a good stimulant but results in a hangover; that an appreciable improvement in ability and willingness to work is apparent after several Finnish baths and exposure to sunlight.

Dr. Henschke proposes that Finnish baths and artificial sunlight be provided at every fighter and bomber base to keep pilots and crewman physically and mentally keyed up without resorting to drugs, which he believes will result in less drinking and smoking and less desire to have intercourse with women..

8. Selection and training of operators of remote controlled bombs and guns.

The principal physical requirement is that of visual acuity. Vision in the better eye should be 6/4 and in the poorer eye 6/6. This requirement was never actually instituted.

The technique of guiding the flying bomb consists of keeping the bomb between the bombadier and the target through out its flight. Reference points for determining changes in response to the steering mechanism are important. Grid lines on the sighting window are satisfactory for this purpose. A small rocket is automatically set off 3 seconds after the bomb leaves the aircraft and burns for 10 seconds. This increases the speed of the bomb and causes it to come within the sight of the operator.

Two synthetic trainers were used. The electrically actuated trainer was mechanically unsatisfactory. A simple mechanical trainer was devised by Dr. Henschke. It is a box containing a glass covered tray about 14 inches square. A square and target are marked on the tray. The tray contains a steel ball about one inch in diameter. The tray is controlled by means of a stick extending from the back of the box. The trainer sits in back of the box with the control handle between his knees. He looks over the box at a mirror across the room. In this mirror he sees the reflex-

tion of the tray from the lid of the box. This trainer was made simple and inexpensive so that large number could be procured.

The trainees are instructed with the instrument in small groups for four hours a day for four months. It has been observed that generally the slower students at the beginning are generally the better ones at the end of the training period.

9. Small Orientation

The special sense of vision is divided into four phases as follows: 1. Visual acuity; 2 Finding; 3. Recognition and 4. Small orientation. The first represents the function of the eye as a special sense organ. The latter three represent cerebral function which within reasonable limits are independent of the first.

Small orientation means the ability to locate oneself in relationship to direction and ground. For example: a good mountain-climber knows which direction is north and his exact location in relation to the surrounding country. An example of a person of poorly developed sense of small orientation is the person who frequently gets lost and has difficulty in finding his way.

Dr. Henschke and his co-workers believe that this function is exceedingly important in aviation and that this sense can be improved through training. They are interested in doing research on this subject.

10. Pilot Fatigue, the capillary system and nutrition.

a) Pathological changes in capillaries.

Capillaries of individuals in good health always have a characteristic shape, consisting of two parallel arms connected by a curved arm. Under pathological conditions resulting from physical fatigue, wounds or surgical operations characteristic morphological changes occur, such as crossing of the parallel limbs and alternate regions of constriction and enlargement. These pathological changes are evident also during the existence of the foehn, when the hot dry winds come down from the mountains; these foehn changes are attributed to electrical conditions set up on the body.

The morphological changes are accompanied by

physiological changes; i.e. changes in semipermeability relations, so that fluids diffuse out quite readily but are resorbed much more slowly; changes in the rate and manner of flow of red blood corpuscles, changing from a smooth consecutive flow of corpuscles to a jerky conglomerate flow of corpuscles. The difference in the rate of diffusion can be measured by the negative pressure required to suck blood out through the skin; for normal subjects the pressure is about 100 to 120 mm Hg. and for pathological subjects it is considerably less. Such a test manometer can be readily obtained by slight modification of a standard sphygmomanometer. This may be a practical field test, if it is deemed necessary, to ascertain the validity of subjective symptoms of fatigue.

Clinical experiments have been conducted on the relationship of this pathological capillary picture to operation, recovery from operations and illness and absolutely fresh vegetables which have a high content of anxins, vitamins etc. Cler-out data on these relationships have not been obtained, but general observations do exist. These are: 1.) on days when foehns exist, many doctors in this region refuse to operate because they have learned from experience that chances of recovery are not as good; 2.) Patients with a good capillary picture recover more rapidly than patients with a pathological picture; 3) Patients whose diets contain a good proportion of fresh vegetables have a more rapid and better recovery.

Altitude Adaptation.

Information obtained from Dr. U. Henschke (Captain, Medical Corps C.A.F. and Dr. A. Frank, Captain, Medical Corps, C.A.F.)

Observations on increased altitude by exposure to altitude have been made by Dr. Frank during the past year and one-half. Thirty C.A.F. flyers were observed every two weeks during this period.

The increased tolerance was produced by living in the Bavarian mountains at 3,000 meters for a period of 11 to 14 days. During the time physical exercise is essential. Greater altitude is considered to be better but facilities were not available.

This exposure increased the altitude tolerance both when breathing air and breathing 100% oxygen about 1,000 meters. The principal test used to demonstrate this was the hand writing test. 13,000 meters is considered the maximum altitude for flight without pressurized oxygen or without a

pressure cabin and this procedure increases this altitude. The increase in the red blood bells and hemoglobin accounts in part but not completely for the increased tolerance.

The increased altitude tolerance was maintained by exposure to 5,000 meters in a low pressure chamber for 1 hour every day. This was done for as long as two months and it is thought that it might be maintained even long as six months. Reduced susceptibility to aero-embolisison is thought to also occur but this is not definitely proved.

Dr. Henschke has used a breathing exercise which increased the blood hemoglobin concentration and he thinks it may be useful for increasing altitude tolerance or for maintaining an increased altitude tolerance. The exercise consists of taking a deep breath and holding it for one minute then breathing for 15 seconds and repeating. The exercise is done for 30 minutes twice a day. He thinks that the mild anoxia so produced is the mechanism which increases the hemoglobin concentration.

Medical Research Institute

Garmisch-Partenkirchen

A. Aviation Medical Research

1. Aiming by use of sights.

Authors: U. Henschke, P. Karlson, J. Zott.

Sights are interesting from the medical point of view, because a good adaptation of the sight to the observer often give an increased accuracy, which can never be reached as easily in a purely technical way. Therefore sight-investigations are important in wartime (guns, cannons, bombs, aircrafts remote controls) as well as in peacetime (modern machines and instruments).

We tested all forms of sights (mechanical-, reflex-, telescope-, periscopes-, and infrared-sights) for standing and moving targets. Usually we worked with a mercury arc lamp connected with the tested sights. Light of the lamp entered a photocell, which was placed at the end of a rotating rod. The rotation velocity could be changed. The current of the photocell actuated a counter and a clock, which turned only when the photocell was active and gave the accuracy at the end of the experiment directly in % (figure).

It was possible to suggest better sights for guns and aircrafts. By means of other investigations we tested normal bomb sights and developed auxiliary and telescope sights for remote controlled bombs and rockets. Fighter gunfire errors were also investigated.

2. Controls

Authors: U. Henschke, P. Karlson, J. Zott.

Modern machines and modern arms are not actuated by man's power, but are motivated mechanically and man has only to control the movements. Accuracy of control is marked dependent on the form of the handles. Here arises a medical problem of highest practical importance, which is not treated up to date either from the medical or from the technical point of view. The first investigations have already indicated that medical research in control made it possible, to increase accuracy of aiming in machines and arms in a striking manner.

The method used for testing sights was used for testing handles. Handles were tested during long accelerations (centrifuge) and short accelerations.

At first the accuracy of direct steering (Wegsteuerung) and of indirect steering mechanish (Geschwindigkeitssteuerung) was compared with different subjects, different types of training, and different velocities of target, to give foundations for the selection of the best method for the several purposes. Combined Controls (Weg-Geschwindigkeitssteuerungen) gave the best results.

Secondly it was attempted to develope the best handles for the different machines and arms, such as guns, bombsights, remote controlled bombs, rockets and radar. A new steering mechanism was proposed for use in aircraft where the horizontal motion is also controlled by hands. Feet and legs are used for heavy work and they cannot make fine adjustments nearly as well as the hands. A second advantage is that the contact between man and machine is closer. A third advantage is the ability of the pilot to bend far forward since the legs may be drawn under the body. This permits the head and heart to be nearly on the same level and increases the tolerance of "g".

3. Observation.

Authors: S. Gerathewohl, U. Henschke, J. Katz.

Oculists chiefly use the visual acuity to test the function of the eyes. Visual acuity, however, is only one function of the eye and a very simple one. It does not say much of other functions which are important for aviators.

These higher brain-connected eye functions are:

a) Finding of objects
b) Recognition of objects
c) Orientation

Different methods were developed to test these functions. Experiments need great care and the results are variable because the brain functions are of great influence. In contrast to the visual acuity, these functions can be very well trained. Therefore investigations of the higher eye functions are of the greatest practical value to aviation, as the "Rhenshaw system" shown in the AAF. A similiar method was developed for training to recognize objects. For fighters as well as for bombers it is the chief task to find other aircraft in the sky. The recognition times vary

enormously, but good fighters had very short ones. Orientation without instruments is also necessary for fighters, bombers and reconnaissance aircraft.

4. Telescopes for aircraft use.

Author: U. Henschke.

Common binoculars are of no use in aircrafts. The chief reasons are:

a) Moving and trembling of the binoculars.
b) Difficulty in finding the target, which must be observed.

Sence physiological investigations were conducted to test visual (Sehschärfe) and moving visual acuity (Bewengungssehschärfe) during moving and swinging of telescopes. Different technical methods were tested to avoid moving and trembling of telescopes and to find the target quickly.

A remarkable sense physiological result is that the moving visual acuity is very much more disturbed than visual acuity if the telescope moves or swings. This gives the indication that aiming by means of sights using a moving telescope is considerably worse than using the naked eye.

A monocular telescope with a ring sight before the unaided eye was developed. It is of great value in aircraft and it is very easy to make two of these observation telescopes for pilots from a normal binocular.

Rules for use of telescopes were determined. Investigations in focussing of telescopes and periscopes showed that it is better for aviators to have a fixed focus.

5. Blinding.

Authors: U. Henschke and J. Katz.

In civil as well as in military life it is necessary to read instruments or maps during night flight and simultaneously observe outside. To disturb the dark adaptation by blinding of instrument or map light as little as possible, first one will choose as low an intensity of blinding light as is sufficient to discern instruments and maps. Secondly one can try to select a blinding light color which does not impair dark adaptation.

According to theoretical considerations of the spectral sensitivity of cones and rods it was often proposed to use a low intensity red light for instruments and maps which is still perceptible by the cones but does not disturb the rods. However, distinct test results do not exist. Therefore experiments were conducted using monochromatic light.

Experiments using a "finding test" gave results, which are condensed in the diagram. First one sees that it is not the dark red, as was generally supposed, but the wave band of about 8400 A that is the best color to avoid blinding. It is remarkable too that the blinding occurs if the blinding light falls in one eye and if observation occurs with the other one.

Hence, results showed that blinding and adaptation disturbance are two principally different phenomonona. Adaptation disturbance is based on chemical processes in the retina, whereas blinding is based on processes in the brain.

6. Night Adaptation.

Authors: J. Fuchs and U. Henschke.

Good dark adaptation is important during night flight for pilots, bombardiers, gunners and also for the antiaircraft batteries. Therefore, it is necessary to search for new ways, which can increase adaptation or permit adaptation in a shorter time.

The following possibilities were tested:

a. Monocular adaptation: The adaptation state of both eyes is nearly entirely independent, so it is possible to achieve an extraordinary improvement of dark adaptation by closing one eye.

b. Heating of the skin zone (head's zone) of the eyes. It is well known from physical therapy that it is possible to get more blood in the internal organs by heating the skin in the zone which is in nervous connection with the internal organ. Thus it may be possible to increase the dark adaptation by heating the skin.

Experiments showed: Adaptation is not finished after one hour. It seems to increase for several days. Adaptation in winter is better than in summer. Therefore it may be possible to reach a very high adaptation by monocular

adaptation. A well trained man is not very troubled by seeing only with one eye. Monocular adaptation can be applied in civil life as well as during military missions (guards, antiaircraft, aircraft gunners) advantageously and by simple means.

By heating the skin between the ears a speedier adaptation seems possible. It is not quite clear at the present time if the degree of adaptation is also influenced.

6

7. Improvement of efficiency.

Author: U. Henschke.

In wartime as well as in peace time it is important to know the influence of physical and chemical means on man's efficiency. Therefore, a great number of experiments were conducted with practically all known means.

The means were tested at first with great care by eight psychological tests. Eight soldiers were trained during four months. Besides the tests a psychological investigation was made. There were some interesting results, but in the laboratory it was impossible to see the right effect. Therefore experiments were made in difficult and dangerous sports, especially ski-descents, climbing and tennis. They were very successfull.

As results of general interest the following is mentioned:

1. There is a characteristic difference between Caffeine and Pervitin considering their psychological effects. Caffeine produces a feeling of excitement and unrest and renders the person in question quarrelsome. Pervitin in comparison tends to overrate the strength and causes a conciliatory mood.

2. Combination of Caffeine and Cardiazol produces other effects and is better than either of the two drugs alone. It is also better than Pervitin because there is no hangover.

3. By combination of the nerve exciting drugs Caffeine and Pervitin with unchaining (Alcohol), compressing (Dolantin) and such means, which produce an euphoric feeling it is possible to achieve in certain cases an essentially higher efficiency than only by Caffeine, Pervitin and Caffeine Cardiazol.

4. Also by physical means (hydrotherapeutic measures such as Finnish bath "Sauna", ultra-violet irradiation) we can effect a considerable improvement of efficiency. With such methods you do not run the risk of getting "a craving" for it and also a true improvement of efficiency is achieved. Physical measures are to be preferred to the chemical ones and deserve a special observation, considering the improvement of efficiency in flying personnel.

8. Selection and training in the process of remote control.

Author: U. Henschke.

One of the most difficult tasks in new arms is to handle remote controlled guns, bombs and rockets. Therefore selection and training of operators of remote controlled arms need great care, particularly, because it is possible to select good men out of a great number.

Investigations were conducted not only in these special functions, but also the rules and foundations of selection and training were exploited. It was tried to get general directions for selection and training with several methods.

The chief physiological points of view which must be considered by the technician to build effective instruments, were also evaluated.

All the first operators for remote controlled bombs were selected and trained by us. Rules were given for selection and training and a very simple trainer was developed.

9. Psychology of aviation.

Author: S. Gerathewohl.

In addition to other psychological questions we worked especially in the three following problems:

1. Instrumental flight. One of the main difficulties in blind flying is the fact that the unity of equilibrium, touch and sight is destroyed by misleading reactions of the vestibul apparatus. Through it the subjective feeling is contrary to the objective indications of the instruments. These sensations also should appear by means of rotations on a revolving chair and therefore a revolving chair was constructed to investigate those sensations and to test the aptitude to control the position by means of instruments only.

2. Orientation: During the first flights across country pilots often lose their bearings and make a forced landing. Therefore it is necessary to investigate the ability of orientation. The object is to select bad orientators and a method to train the senses for orientation.

Because the imaginative faculty of space is one of the important conditions of the ability of orientation, this faculty was tested by means of an orientation test. In this test the pilot had to direct a pointer in the direction to orientation-points seen before the beginning of the test. The divergences of angles are plotted to a curve.

3. Sensibility of flight: Sensibility is one of the conditions for good flying. It is arranged by perceptions of equilibrium, touching, feeling and moving. The haptical sensations in flying are perceived by the surface and depth sensibility and set in action by external responses, interior irritations of surfaces responce, muscle, ligament and organ apparatus of the body. Therefore three tests were used to establish the most important suppositions of flying-sense: Research of the surface-sensibility by means of horizontal rotations and a coordination test for hand and foot movements by means of a sensibility reaction apparatus.

10. Pilot fatigue.

Author: F. Hollwich.

Pilot fatigue is always a great problem of flight surgeons, especially during the war. It would be very important to have objective tests for diagnostic as well as for therapeutic purposes.

We proved and compared the following tests:

a. Changes in capillaries, observed with a capillaries-microscope. Capillaries of individuals in good health always have a characteristic shape. Under pathological conditions resulting from sickness, "foen" (special alpine wind) and also from pilot fatigue, characteristic morphological changes occur.

b. Measurement of the p_H of the blood.

c. Salamander test, developed by Prof. Eppinger, Vienna.

d. Measurement of the permeability of the capillaries by the negative pressure required to suck blood out through the skin. For normal subjects the pressure is about 100 to 120 mm Hg. and for pathological subjects it is considerable less. Such a test manometer can be readily obtained by slight modifications of a standard sphygnomanometer.

By means of those methods we try also to study the influence of bood especially of auxin like substance on pilot fatigue.

11. Altitude adaptation

Authors: A. Frank and U. Henschke

By a stay of at least 11 days in the mountains at an altitude of at least 7000 feet, combined with very much sport, good food and sleep, it is possible to obtain a very good altitude adaptation.

The limit of the adaptated man's altitude tolerance will be between 26000 and 31000 feet on the average without oxygen, although some men get to 33000 feet. With oxygen the limit is 3300 feet higher than normal and man can fly without pressure cabins up to 43000 - 45000 feet. The time reserve of an adapted man at 39000 feet is 1 - 1½ min.

The effects of high altitude adaptation persist 4 - 6 weeks after return to low level, but during this time it disappears slowly. The persistence can be preserved over many weeks by daily ascents to 16500 feet without oxygen for one hour in a decompression chamber.

For testing for altitude adaptation, besides the writing test a great number of psychological tests were also investigated. They gave no better results than the writing test except the electroencaphalogram and the measurement of simple reaction time. For this latter purpose we use a special electrical arrangement, which makes it possible to get a diagram of the reaction time during an altitude experiment.

In addition, it was tried to obtain and to conserve altitude adaptation by breathing exercises.

12. Short Duration Accelerations.

Authors: U. Henschke and W. D. Keidel.

It is important to know the limitations of the human body subjected to "g" forces for various time periods for the following reasons:

a. To study crash injuries and methods for protecting against high accelerative forces.
b. To develop suitable ejection seats.
c. To develop aircraft which ram other aircraft in the air.

We took a great swing between two high trees which was stopped rapidly by a strong cable. The "g" was measured and calculated; the position of the subject in the swing could be varied. The length of time could be varied by the strength of the cable.

For times of 0.01 seconds for seven persons the limitation was measured in different positions. The "g" tolerance changed between 10 and nearly 100 g in different positions. Above these levels concussions will occur. In all cases the limit was believed to have been 10 g sustained by the brain. The best position to avert crash injuries and to develop ramming aircraft seems to be the recumbent position on the back with the feet in the bow.

B. Other Medical Research.

1. Eye-prothesis for blind men.
Authors: U. Henschke, W. K. Keidel

It was tried to use modern technical means to help blind men. Two instruments were developed:

a) A visual-prothesis with a photocell, an amplifier and a sound producer. In this arrangement light is converted into sound. By help of a lens system it is possible to adjust different angles of view. This construction enables blind men to find their way and to obtain sufficient orientation.

b) A visual-prothesis changing the light into a tone in the same manner, but combined with an ikonoscope. The picture of a letter or of the surroundings will be palpated in f.i. ten lines during a time space of some seconds. Thereby one has an "ear-image" instead of an eye-image.

After a brief training blind men could read any letter of the alphabet in two seconds. Investigations of other methods showed, that this method seems to be the best one to read normal letters and also to recognize landscapes. Experiments to use the skin as receptor were not so successful.

2. Extremity - prothesis

Authors: U. Henschke, W. D. Keidel

To develope modern extremities prothesis, it was tried to use technical power (magnetic, electrical or hydraulics or pneumatics) for moving artificial legs. The patient has only to control these powers. This is the way in which the modern technical science generally has achieved excellent results and which, we think, will be decisive for the further development of the construction of extremities-prothesis.

To control the technical powers, first the power of the muscle stumps or of other muscles was used. Secondly it was tried to take off the current of the nerves of the amputated leg, which has a characteristical form and power for each motion and which can be amplified.

At first, an artificial hand, which is moved by a magnet and controlled by the muscle stump of the hand and an artificial leg with a knee, which can be fixed in every position by help of a magnet (which is controlled also by a muscle stump) were developed.

3. Origin and treatment of cancer.

Author: U. Henschke.

Cancer nowadays is a most dangerous disease. In spite of the great number of investigations already made we do not know much about the origin and the best treatment of cancer. It would be we suppose, of greatest importance to have good work-theories for further research as well as for practical treatment.

We used the modern genetic theories and our own experiments for these purposes. First, we developed a theory according to which the origin of a cancer cell is a spontaneous mutation and all the known cancorogen noxes (mechanical, chemical, actinical and chemical means) only damage the healthy cells, so that cancer cells can develope without resistance. Normal cells are often changed to cancer cells in the tissues, but the normal cells usually fight them. Only when normal cells are damaged cancer will develope. Mutations only allowed for evolution of animals, therefore from this theory, cancer appears as a by product of an event which is necessary to permit evolution to take place.

(Publication: U. Henschke: Tumor theories and the possibility of origin of tumor cells by spontaneous mutation. Z. F. Krebsforschung 54 (1943) 11.

Nowadays we work on experiments and theories to get a clear picture of the effect of short waves (X rays, alpha, beta, gamma rays, neutrons) on cancer. According to the new genetic theories, we try to give a theory which explains the effect of rays in different conditions (wavelength, fractioneering and protrahiering, distribution in the room, heat and cold) and which can give the rules for the best form of ray-treatment for every form of cancer.

APPENDIX VI

Interrogation Report, Messerschmitt AG
Oberbayerische Forschungs-
anstalt.

Subject: Pressure Cabins and Pilot Ejection Seats.

Personnel interrogated: Dipl. Ing. Waldemar Voigt.
Ing. Josef Helmschrott
Ing. Walter eidel
Ing. Hans Keller.

Results of Interrogation:

A. Pressure Cabins.

German Military requirements did not absolutely require a pressure cabin because enemy aircraft did not fly high enough. However, the Messerschmitt engineers developed a pressure cabin for the Me 109. The Me 109 went into production with a pressure cabin in 1942 but was discontinued somewhat later because of the lack of necessity for it. Design for a pressure cabin for the Me 262 was similarly a design undertaking, in the event a requirement arose.

Initially the cabin pressure was maintained at 0.5 atm at altitudes above 18,000 feet. Later this was changed to 0.3 atm for the following reasons:

1. Less weight and simplified design.

2. Less gun-fire hazard.

3. Decreased rate of explosive decompression.

4. Personnel in cabin were required to use oxygen at all times. Hence, it was essential to maintain a cabin pressure only below the level of high incidence of aero-embolism.

Ventilation in Me 109 pressure cabin was at the rate of 12 m3 per hour. The incoming air was directed against the plexiglass interior to keep airfaces clean of moisture. Only the windshield part of the canopy consisted of a heavy bullet proof outer layer, 90 mm thick, and a thinner inner layer. To prevent condensation of moisture when ventilation stopped electrically heated wires were located on the bullet proof shield.

Temperature regulation of air ventilating the cabin was not necessary in the Me 109, because a separate compressor was provided, which did not run too hot. On the Me 262 the air obtained from the jet engine compressur was hot at low altitudes and cooler at high altitudes. Temperature was regulated by heat exchange and by an expansion turbine. This method worked satisfactory and was built by Schäffer & Budenberg in Magdeburg. The expansion turbine was also used on Me 262 without pressure cabins to cool the cabin during flight at low altitude at high speeds.

Regulation of cabin pressure was obtained by three regulation mechanisms:

1. A pressure holding valve which was controlled by an aneroed and which sealed off at a predetermined altitude e.g. 7 km.

2. A positive pressure valve which kept the pressure differential at the prescribed level.

3. A safety pressure valve, to prevent the cabin pressure from rising too high.

4. A negative pressure valve, which equalizes the cabin pressure when the atmospheric pressure outside is greater than the pressure inside the cabin, such as would be the case in a rapid dive from a high altitude. The operation of the pressure control valves in the Me 109 during actual flight are indicated in a report of flight test results, dated 109-17-E-42.

Additional reports on the control valve function of the Me 262 exist but are in the hands of the French, as well as drawings of the latest control valves. Attempts are being made to recover these documents.

Interrogators: Col. W. R. Lovelace
Lt. V. J. Wulff

Report of Interrogation

6/5/45

Subject: Ejection Seats.

Personnel Interrogated: Same as on previous report.

Results of Interrogation:

A. The dangers involved in the rapid ejection of pilots are:

1. Prevent the occurence of high negative "g" during the ejection by rotation of the seat.

2. Prevention of striking any part of the cockpit by the person during the ejection.

3. The effect of max. "g". 20 "g" is considered safe by engineering personnel when acting in direction of head to foot; 3-5 "g" is maximum when acting in direction of foot to head.

4. The effect of ram pressure on the face, body and respiratory tract.

It was the considered opinion of these men that pilots have successfully escaped from high speed aircraft but that ejection seats would perhaps increase the number of successful escapes.

Concerning the Me 262 versus the P-51 the following factors gave P-51 the edge.

1. Many P-51 pilots had anti-"g"-suits.

2. Me 262 had a constant thrust regardless of speed which extended the radius of turning.

3. The Me 262 had a high wing loading which limited tightness of turns on spirals.

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APPENDIX VII, EX A.

Freising 12 June 1945

Interrogation Report

Subject: Research Conducted on Problems Related to Aviation Medicine.

Persons Interrogated: Prof. Georg Waltz and Dr. Robert von Werz.

Results of Interrogation:

1. A spectroscopic analyzer for arterial and venous HbO_2.

The instrument consisted of a clamp, a light some and a spectroscope. To obtain a reading the lone skin between thumb and forefinger was clamped off and the time measured for the reduction band of Hb to appear. Dr. Werz claims that the instrument is practical, particularly for use at altitude, where satmation of Hb with O_2 is less. The error of reading can be minimized by training. The instrument was proposed to replace the pilot's resistance to anoria test, 7% O_2 ± 93% N_2 heated until collapse. During development of this instrument it was determined that reduction time variez with the pN of the blood, increase in pH decreasing and decrease in pH increasing the reduction time for a constant saturation of heoglobin.

2. Research on Effect of Immersion and Recovery.

Several reports of deaths resulting from cooling down of the body due to immersion in water led to the opening of this project. The first discovery was that recovery obtained by rapid rewarming of the cooled animal did not produce the collapse reaction which was so widely described in literature. In fact the deaths are less from rapid rewarming than from slow rewarming.

The two theories of warming collapse were tested by means of parabiotic twirs of which one was cooled-rewarmed. During cooling, the controlled parabiotic circulation was clamped off and this clamp was removed with rewarming. With slow rewarming the cold parabiotic did not recover; with rapid warming the cold parabiotic recovered and the control parabiotic showed no ill effects. This

work disproves the two theories explaining the warming collapse and death namely; dilation of periphecal vessels and development of stock and the sudden rapid circulation of histamine like substance accumulated in the stagnent blood stream. Rapid warming of animals cooled to lethab temperatures resulted in great recovery than slow warming.

Investigations were conducted to determine the exact cause of the death resulting from lowering of the body temperature. All of the possibilities were examined, loss of respirature, slowing of circulation, failure of fundamental reflexes, anoric death, etc. Through a series of controlled experiments and examination of pliterat use it was finally determined that the cause of death was anozia. This anoric death results not from slowing of the circulation but from a greater affinity of hemoglobin for O_2, which did not reduce the O_2 concentration of the blood, but did greatly reduce the O_2 tension of the tissues. This theorie was later confirmed by Lutz, who cooled animals in a high pressure O_2 environment (2-3 atm), there increasing the amit of oxygen dissolved in the plasma, to the point where the heart ceased beating for varying lengths of time up to 1 hour and produced complete and incomplete recovering.

Further experiments were performed to determine the rate and magnitude of coloric loss and uptake of living and dead animals upon cooling and rapid warming. The purpose of this experiment was to determine whether the loss of heat resulting from the heat capacity of the body was more important than the loss of the heat which results from the metabolic processes going on during the time of immersion. The experiments indicated that during a 2 hour cooling period, the greater part of the heat lost was from the heat capacity of the body, and this quantity of heat is very rapidly absorbed during rewarming, if sufficient heat is supplied.

The practical considerations which emonate out of these experiments are; 1) To prevent death from immersion it is necessary, to conserve the heat which the body has stored as a function of its heat capacity; this means all available clothing should be worn in the water and a water proof insulating immersion suit be provided; 2) During immersion as little activity as possible should be indulged in and the minimal surface area should be exposed to the water; i.e. the victim should double himself up; 3) To obtain recovery from immersion rapid rewarming is required. If a hot bath (40^{o} to 45^{o}) cannot be provided, hot water should be poured inside the clothes of the victim; 4) Simultaneously with application of heat artificial respiration should be instituted (reasons given later). 5) Use of alcohol

in producing recovery from immersion does not help in pigs but may possible aid the human.

3. Research on Oxygen Poisoning.

Confirmed the earlier results of investigations on this topic that oxygen under tension between 2 and 3 atmospheres produces illness and death. However, the pathological picture resulting from this type of death is similar to death by CO_2 asphyxiation. It is, therefore, the belief of these men that increased O_2 tension of plasma and hemoglobin does not permit the blood to carry back the CO_2 to the exchange point at the lungs and, therefore, that death results from CO_2 intoxication.

4. Research on gangrene.

Since gangrene is caused by an anaerobic bacteria it has long been considered that O_2 application may be a cure since anaerobic organisms die in O_2 environments. Various methods had been used since the last war, but none of them successful, primarily because many of them supplied atomie rather than melocular oxygen. Experimental gangrene was introduced into guinea pigs and the animals were placed in high O_2 environment. No success. Then the animals were first treated with intramuscular injection of sulfonamide and subsequently treated with high O_2, pressures and this treatment resulted in a prolongation of life by 2 or 3 times the untreated life span, but no recovery.

Person Interrogated: Dr. Wolfgang Lutz.

Dr. Lutz is a young man and very enthusiastic young man. He has carried and directed his research program with considerable brilliance and has obtained results which appear to the sound and based upon adegrate experimental evidence. Of the 3 men investigated at this target, Dr. Lutz seems to be the most capable.

Lutz has worked primarily and three distirect problems: 1.) High altitude parachute excape with and without oxygen; 2) Recovery from apparent outcome high altitude death and 3) Recovery from apparent death resulting from lowered body temperatures. In addition, he has expressed several ideas about some items of equipment and has developed an expired air collecting and dumping valve.

1. Valve for collecting expired air of sulyects in a decompression chamber.

The purpose of this valve is to prevent the accum-

ulation of O_2 in the chamber and thereby lower the effective altitude. It consists of a collecting manifold into which expiratory ask hoses are plugged and a constant pressure differential diaphragm operated valve, which may be trade to produce different expiratory resistances. At lowest setting the expiratory resistance is about 1-2 mm H20 col. at 201/min. flow.

2. Emergency Pressure Suit.

The actual use of the pressure suit was to be limited to emergency use, such as when cabin altitude increases suddenly by puncture or other causes. The pressure in the suit was to be maintained at 140 mm Hg abs. and could therefore be of a light weight construction; and this pressure did not stiffen the suit too much at altitudes of 50 to 60,000 feet. The operation of the suit was to have automatic upon pressure in the cabin and the O_2 flow regulating mechanism was to be incorporated in the suit. The design and patents on this suit were sold to the Draegerwerke, Lübeck, whose developments on this suit are described elsewhere.

Lutz had built a suit along these general lines for use in a rocket propelled glider, where the pilot was lying supine, his helmet supported, and his head supported by a chin rest inside the helmet. Mask and regulator were dispended with by providing a constant flow of O_2 which prevent the accumulation of moisture and maintained the cabin of pressure, which was not maintained from any other source. The increased fire hazard of higher oxygen tension inside the cabin at extreme altitudes was checked in the decompression chamber and found to be not greatly increased. The end of the war did not permit completion of this project.

3. Ejection Seats.

The narrow cockpit exit, through which pilot and seat must go, presents danger of breaking the extremities, Lutz recommended that the catapult releasing switch be located on the stirrups, so that the feet must be in proper position before ejection can occur. In order to avoid the high accelerative forces which occur during the catapulting Lutz suggested that: 1) the pilot be lifted out of the cockpit by a spring activated fork which is anchored near the tail; 2) that explosive mechanism be built into the tail so that this tail assembly can be blown from the aircraft and permit the pilot to escape without danger of hitting these surfaces.

4. Recovery from lowered body temperature.

It has been previously described that death from lowered body temperature is most likely death from anoria. The source of this assumption is twofold; 1) a greater affinity of hemoglobin for O_2 as temperature drops; 2) a vital increase in metabolism as the body temperature drops. This creates a greater than normal demand for tissue O_2 at a time when the availability is already decreasing.

When guinea pigs are placed in a cold bath they become more and more shiggish and at a critical body temperature of ca 15° C exhibit a singular gasping reaction. Rapid rewarming before or at the beginning of this period will produce recovery, but rapid rewarming after this period always is unsuccessful, even though the heart beat may continue for some time if the animal is left in the cold. Upon recovery, these animals will revive somewhat, the heart rate picks up with a very peculiar electrocardiogram and finally stops.

Since anoric death was indicated in these cases it was attempted to lower the body temperature of animals in a high pressure oxygen environment. O_2 pressures of 2,7 8/6 atmospheres were tried. Oxygen poisoning produced some effect particularly at temperatures at or near normal. But in the lethal temperature range the hyperoxygenated plasma produced a considerable effect and extended the critical period of 15° C restal temperature by as much as 100 to 200%. However, this beneficial effect was optimal for O_2 pressure of 2 to 3 atmospheres; above this pressure death resulted from O_2 poisoning in the upper temperature range and there was a decreased beneficial effect in the lower temperature range. To find an explanation for this the reaction of the heat was studied by means of the electrocadiogram.

During the cooling process the ekg remains quite normal but the frequency decreased and the distance between the Q-R waves, the R-S and Q-T waves increases. The frequencies and distances were measured for various body temperatures and plotted. The frequency had a linear relation to temp. and the distances of the various waves a hyperbolic relation. The inverse function of these distances gave rise to a linear relationship and the inverse function of the frequency gave rise to a hyperbolic relation.

The peculiar significance of these hyperbolic functions is that they indicate that the heart never stops beating, since a hyperbolic is asymptotic to the abscissa, but that the time between beats becomes greater and greater.

This meant that these were all expressions of

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velocity of conduction of the excitation through the musculature of the heart, and that these velocition decreased linearly with temperature. It was further noted that the linear frequency curve indicated the zero ordinate at 16° C and the linear $\frac{1}{Q-T}$ relation interseated the zero ordinate at about 10° C. This indicated that the electrical stinculus for the heart beat stopped while the musculature still had the possibility of conducting an impulse. This indicated that electrical stimulation of the heart could possibly aid in restoring life to these apparently dead animals - and this was indeed the case. If the heart was stimulated electrically during rewarming and if an O_2 environment of 2-3 atm. had been used, recovery of these animals could be obtained, even if their hearts had not been beating for as long as an hour. The recovery was not complete, however, for these animals died after apparently coming to life. Autopsy indicated that gas had been liberated from the blood and had distended the right auricle and ventricle whereas the left ventricle and auricle were completely collapsed. At the same time complete atalectasis of the lungs occurred, also due to the capillaries blowing up because of liberatur of gas. (This liberation of gas results from the sudden drop in pressure from 3 atm. to 1 atm.). Those animals whose thorax was opened for autopsy recovered to the extent that the gas from the heart was restored and the heart began beating. This resulted from opening of the lung cavity(breaking of the stalretasis then thorax was opened for autopsy. It was then attempted to break this atalectasis by artificial respiration with positive pressure up to 20 mm' Hg and it was successful.

These experiments which Dr. Lutz performed and the results he obtained were theoretically interesting and indicated the following practical applications: 1) Rapid rewarming of sub-cooled patients (immersion victims) and artificial respiration with O_2 to supply oxygen to the heart musculature.

5. High altitude parachute escape.

These studies were all made on animals such as mice, guinea pigs, rabbits, etc. The purpose was to find the limiting altitudes for parachute escape with and without oxygen. The explosive decompression method was used to produce the high altitudes desired in a short period of time.

Experiments were first conducted with air only and followed by experiments with oxygen at calculated equivalent altitudes, correcting for the increased rate of fall at the higher altitudes. In all cases the air experiment animals were in better condition than the O_2 animals. It

was finally decided that the reason was that when an animal is rapidly decompressed and had been breathing air, that oxygen boils out of the blood in the alveoli and increases the oxygen tension of the alveoli long enough to be of some benefit.

In connection with these experiments it was determined that at moderate altitudes (40-60,000 ft.) death occurs, after a certain time interval, which is irreversible. At higher altitude, death occurs but it is reversible for much longer period. This required further investigation.

Dr. Lutz continued his studies on the reversible and irreversible death phenomena which occurred at high altitude. He found that between 15 and 20 km animals such as cats and rabbits could exist for several minutes and come back, whereas at lower altitudes death always resulted which was not reversible. The cause of this apparent phenomenon is that the boiling of the blood at these extreme altitude produces enlargement of the heart and blood vessels, so that all circulation immediately stops. This prevents the loss of O_2 from the blood which would occur through the lungs if circulation remained. This pooling of relatively high oxygenated blood in the tissues can maintain life, which returns when the vessels return to normal size as a result of an increase in pressure. Experiments on cats have been performed and indicate recovery to quite normal animals. The irreversible death which results at lower altitude is the result of the loss of oxygen from the blood through the lungs.

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APPENDIX VII Ex. B.

A. Reports on Investigation on High Altitude Physiology by Dr. Lutz and co-workers.

1) Ueberlebenszeit nach Druchsturz in grössten Höben
Time reserve after explosive decompression to very high altitudes. Luftfahrtmedizin, Volume 7, 1st Month, 1942.

2) Tierversuch zum Fallschirmabsprung ars Ueberdruckcabinen
Animal experiments on parachute escape from pressurized cabins. (Not published for unlimited distribution).

3) Der anoxische Scheintodt
The apparent anoxic death Luftfahrtmedizin, Volume 8, 2, and 3 month, 1943.

4) Über die Wirhung von Kohlensäure auf die Erhohlung aus Sauerstoff mangel. Over the effect of CO_2 on recovery from anoxia Luftfahrtmedizin, Volume 8, 2nd and 3rd month, 1943.

5) Die Depressions - (Druchfall) Atelehtase.
The atalectasis produced by pressure drop.
(Not published for unlimited distribution.)

6) Einfluss von Atelehtase und intrathoracales Gasbildung auf die Aussichten der Fallschirmrettung aus Höchen ueber 25 km (82,500 feet). Influence of the atalectasis and introthorarie gas formation on the possibilities of parachute escape from altitudes beyond 82,500 ft. (Not pub'd.)

7) Einfluss der Hoche auf die Wiederbele bung aus Sauerstoffmangel Influence of Altitude on the recovery from effects of anoxia. (Not published).

B. Reports of Investigation on Effects of Reduced Body Temperatures.

1) Die experimentelle Verkaltblüterung des Wärmblüters.
The experimental cooling of warm blooded animals, Klinische Wochenschrift, 1943, 727.

2) Elektrokardiographische Beobachtungen bei Auskühlung des Warmblüters. Eleclrocardiographic Observations during cooling of warm blooded animals. Zeitschrift für Kreislanfforschung 1944, part 22/24.

3) Über die Temperaturabhängighest des Erregungsvorganges im Herzin. Over the depence of heart excitability on the temperature. Zeitschrift für Kreislaufforschung (In press)

4) Über Wesen and Ursache des Herzstillstandes bei Anskü-

hlung Over the Manner and significance of the cessation of heart beat with reduced body temperature. Zeitschi für Kreislaufforschung (In press)

5) Kältetod and Sauerstoffmangel Immersion (Cold death and anoxia Medizinische Zeitschrift 1945, I.

6) Über die Reversibilität des Kältetodes Over the Reversibility of Cold-death. (Not published).

7) Tagungsbericht Report of Conference of October 26 and 27 1942, concerning medical problems of low temperatures and sea rescue. Article on human experiments p 44 by E. Holzlöhner.

8) Physiologische Grundlagen zum Verständris von Wärme und Kälteschäden am menschlochen Organismus by Dr. H. Rein. Fundamental physiologic considerations necessary for the understanding of heat and cold injury in the human organism. Archir für Dermatologie und Syphilis 184 Volume, 1943

9) Über die Kältedilatation der Extremität des Menschen in Erswasser. Concerning the cold dilatation of extremities of humans in ice water By Jürgen Aschoff Pflüger's Archir, 284 Band, 1-3 parts 1944.

10) Krerslanfregulatorische Wirkungen der Kältedilatation eine Extremität als folge extremer, unschriebener abkuhlung. Circulatory regulation effects of dilation from cold in an extremity resulting from rapid and extreme cooling. By Jürgen Aschoff, Pflügers Archiv. Volume 284, part 4-6, 1944.

11) die Vasodilatation einer Extremität bei orilicher Kaltreinwirkung. The vasodilation of an extremity induced by regional effect of cold. by Jürgen Aschoff Pflugers Archiv, Volume 284, part 1-3, 1944.

These articles are available in the following places (other than the Journals indicated).

1. Arv - Medical Laboratory, Wright Field, Dayton, Ohio.

2. Director of Medical Intelligence, Arv - medical Research Section, USSTAF Rear

3. Bureau of Medicine, U.S. Navy, Washington, D.C.

4. RAF Physiological Laboratory, Farmborough, England.

APPENDIX VIII, Ex. B.

INTERROGATION REPORT

18 June 1945

SUBJECT: Physiological effects of intermittent blasts, periodic blasts and supersonic vibrations of great energy.

Personnel Interrogated:

Dr. Kurt Reissmann Dr. Hans Dessaga Dr. Joseph Pichitka	From the Luftfahrtmedizinisches Forschungs, Institut-Branch of Strugholds Institut
Dr. Ing habil W. Ernsthausen Dipl. Ing W. Von Wittern	From Reichstelle für Hochfrequenz forschung, Helmholz Institut.

Location: Brannenburg.

Results : A result from Luftfahrtmedizininches Forchungs Institut.

1. The physiologic effect of blasts on the human body were studied by Drs. Desega and Reissmann to determine the cause of death. The pressure of the compression wave resulted in considerable pulmonary damage and in a high arterial blood pressure shock wave. This work has been summarized in a report which has been published.

2. Reports from the test stands for the Argus intermittent jet propulsion unit (V-1) indicated that personnel working near these units would become ill; i.e. loss of all reflexes and sensitivity in the legs; pulmonary bleeding; nausea; vomiting; and finally loss of consciousness. These effects disappeared upon removal of patient from testing site and caused no apparent damage. It was the opinion of the interrogated people that these injuries and symptons are the results of the periodic pulsations emanating from the Argus tube, and that the symptons were the result of pressure waves and the frequency of vibration. Investigation of this problem was started and the physical measurement of the frequency and energy of vibrations from Argus power unit were measured by personnel of the Helmholz Institut. Their measurements will be discussed later.

3. Verbal reports were also being received that acci-

dents were occuring in Me 262 jet propelled aircraft flying at high speeds near the ground, presumably due to loss of consciousness, of the pilots. It was assumed that this was a similar physiologic effect resulting from the frequency and energy of sound waves. This problem was also to be investigated and the physical measurements of the magnitude and frequency were measured on the Me 262 isolated jet and in the aircraft flying at various high speeds. These will also be discussed below.

4. The works of the medical people on these projects is rather vague, and they seem to have only plans. Apparently they worked together with the Helmholz Institute, but it seems that most of the initiative and ideas are located at the Helmholz Institut. In view of the importance of development in jet and rocket aircraft it is imperative that these investigations be completed.

Results from Interrogation of Helmholz Institut, Reichstelle für Hockfrequenzforchung.

1. Condensor microphoes, amplifying and recording equipment were developed and built. These instruments were used to measure and record the frequency and magnitude of the vibrations obtained from the Argus tube and the jet engine used on the Me 262.

2. Results from measurement of the intermittent pulsations of the V-1 power unit indicated a very high energy wave with a frequency of about 50 cycles per second. High frequency components were present, but their energy content was lower. The greatest energy was recorded at the front left hand side of the tube. It is the belief of these men that the physiologic ill effects are caused by this relatively low frequency high intensity periodic vibration. To tackle this problem a preliminary experiment was planned to determine the resonating frequency of the human thorax, since such a reasonance may explain the deliterious effects. Preparations have been made but no tests have yet been conducted. The test set-up consists of two cement cylinders, reinforced with iron. These cylinders have two openings into one of which a vibration of known frequency and magnitude is introduced, and the second of which are coupled across a condenser microphone. One of these chambers holds a human being immersed in water up to the abdomen and the other is empty. The condenser microphone bridge is balanced out with both chambers empty and any subsequent changes in this reading indicates changes induced by the presence of the human body. If a great increase in the magnitude of the vibrations takes place, resonance is indicated.

3. Measurements of the magnitude and frequency of vibrations obtained from the Me 262 jet and Me 262 in flight were made. The results indicate that the average magnitude of vibrations in four regions, 10, 15, 22, and 34 thousands cycles per second are greatly increased when the jet propelled aircraft is in flight. About a four fold increase in intensity of all four bands exists at 950 (594 mph) Km per hours. The intensity increases steadily with increasing speed. It is indicated therefore that the physiological effect of these high energy supersonic vibrations be investigated.

4. A study is under way to minimize the effects of periodic vibrations of the V-1 power units by using two tubes operating 180 degrees out of phrase and utilizing interference to reduce the magnitude of the pressure waves. This study is to be carried out using air blasts and the intermittency is produced by a rotating valve whose speed is controlled. The experimental set up is just being completed at the Institut and as much work is being done as is possible under the existing conditions.

5. Dr. Ernsthausen believes that the sound waves given off by intermittent or continuous jet engines is lost energy and accounts for a large part of the efficiency lost in these engines. Proper design of the jet can increase the efficiency of the engine and it is believed that further research on these lines is essential for further developments of this type of propulsion.

Scholldruckmessungen an einem Argus - Triebwerk

1) Sound pressure measurements on an Argus power unit. by Dr. Ing E. Franke, Helmholz Institute.

2) Ultraschollmessunger in einer Flugzenghobrne Supersonic sound measurements in an aircraft cabin (in flight) Dr. Ing E. Franke, Helmholz Institut

3) Kreislauf und Armungbeim Detonatronstod Circulation and Breathing before death from detonation. Experimental Station, Rechlin, 1944

4) Die Luftstossverletzung des Menschen unter Besonderer Berucksichtigung der Schutzmöglichkeit by Dr. Desaga. The Air pressure injury of men and considerations for protective measures.

5) Über die Wirkung von Schwingungen auf das vegetative Nervensystem und die Schvenreflexe. Concerning the effect of vibration on the vegetative nervous system and the tendon reflexes by Dr. Loeckle. Deutsche Versuchsanstalt für Luftfahrt 10 Sept 1940.

Subject: Interrogation Report.

Place: Forschungsanstalt, Graff Zeppelin.

Location: Ruit, southeast of Stuttgart.

Personnel: Dr. Ing. Helmut Heinrich
Dipl. Ing. Theodor Knacke

Results of Interrogation.

1. Dr. Ing. Helmut Heinrich

This man was chief of the aerodynamics section in the institute and had charge of all wind tunnel, cannon and parachute drop test work, bombs, bomb carriers and guided missiles. The activities of this man will be described in their order of importance from an aero medical point of view.

A. Development of a stabile parachute.

Dr. Heinrich was given the problem of investigating the fundamental physical characteristics of parachute opening and falling characteristics. These studies were performed on the conventional Irving canopy in a wind tunnel. The investigation revealed the physical forces which cause the conventional semi-spherical parachute to pendulate and to fail to open. Fig. 1 on the following page illustrates the turbulant flow characteristics of a vertically descending conventional parachute; figure 2, the flow characteristics when the direction of flow departs from the vertical. A pressure difference is set up between the two sides which causes the upward component of force to deviate from the verticle. The swing to the side increases until an angle of incidence of wind on canopy is reached which offsets the pressure difference, causing the upward component to shift to/the vertical position. Since the parachute now has momentum it will swing past the vertical to the other side, and this pendulation will continue. This pendulation may also take the form of a circular pendulation rather than a side to side pendulation. These results indicated to Dr. Heinrich to provide a parachute with guide surfaces. Such a parachute is presented in figure 3 of the following page. The parachute consists of a canopy and a peripheral straight portion which tapers inward. It is this portion which acts as a guiding surface and numerous wind tunnel and parachute drops tests indicate that it is absolutely stable. The action is such that when the direction of flow is changed , the force on one side of the guide surface will be greater than the other and the chute will move until it is again in equilibrium, but it will remain

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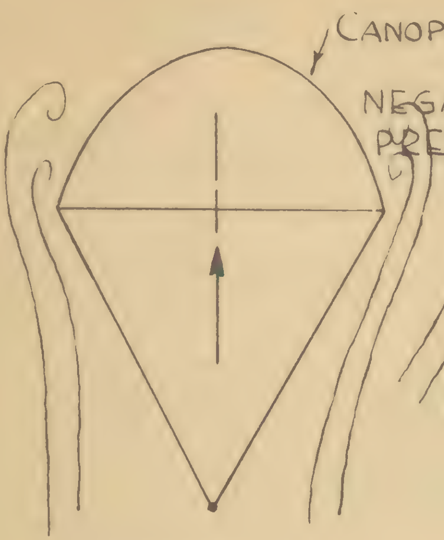


FIG 1

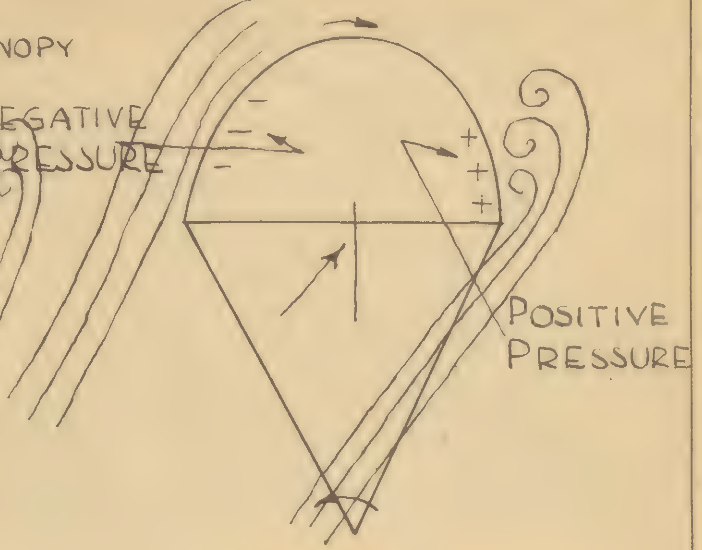


FIG. 2

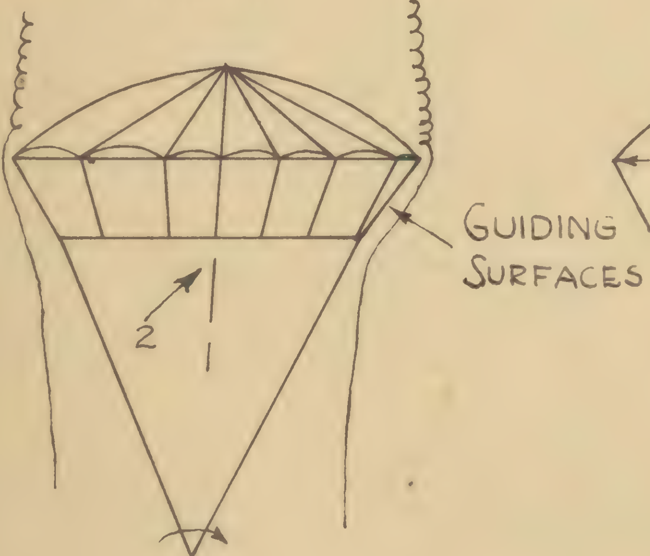


FIG. 3

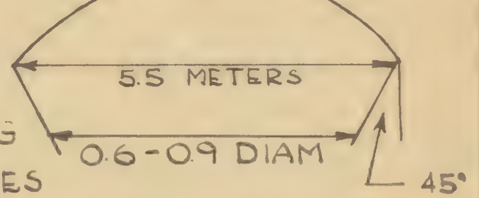


FIG. 4

1 = $C_W \cdot F \cdot Q$

2 = $1.3\ C_W \cdot F \cdot Q$

3 = $2\ C_W \cdot F \cdot Q$

WHERE

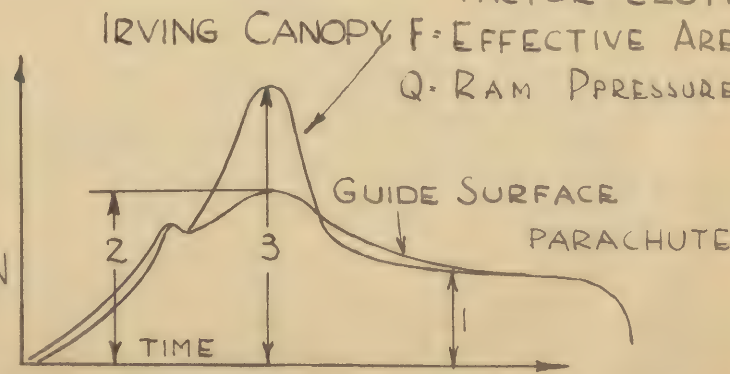
C_W = RESISTANCE FACTOR-CLOTH

F = EFFECTIVE AREA

Q = RAM PPRESSURE

'g'

ACCELARATION TIME CURVE



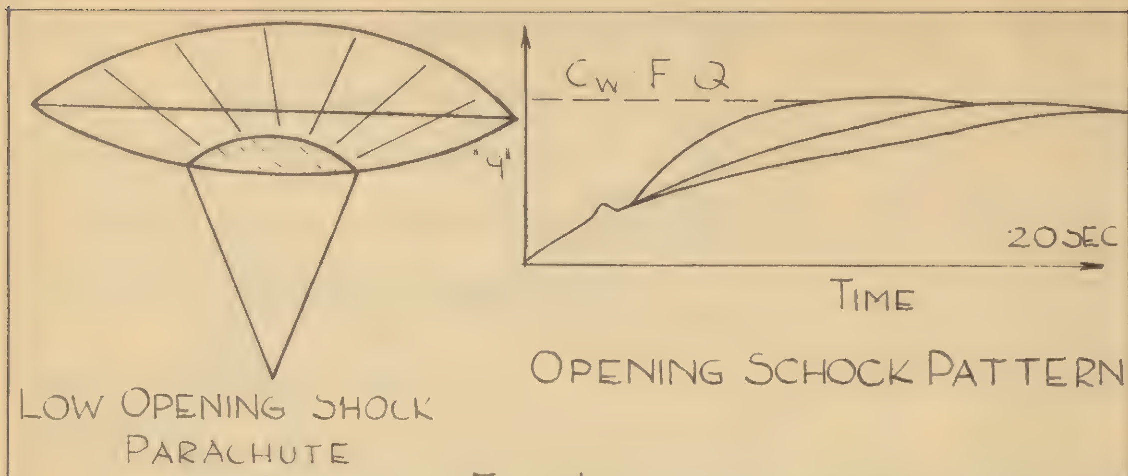


FIG. 1

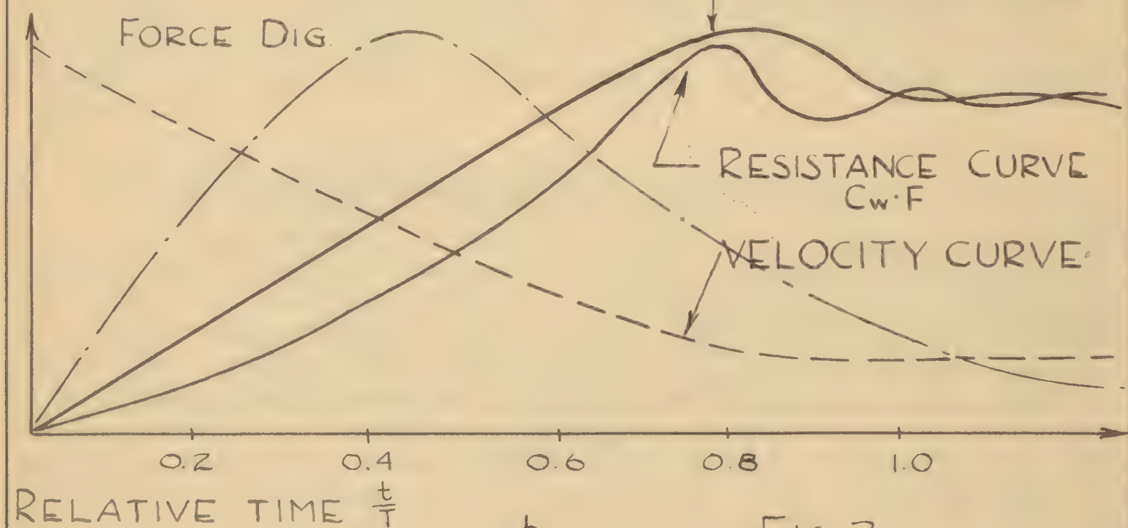


FIG 2

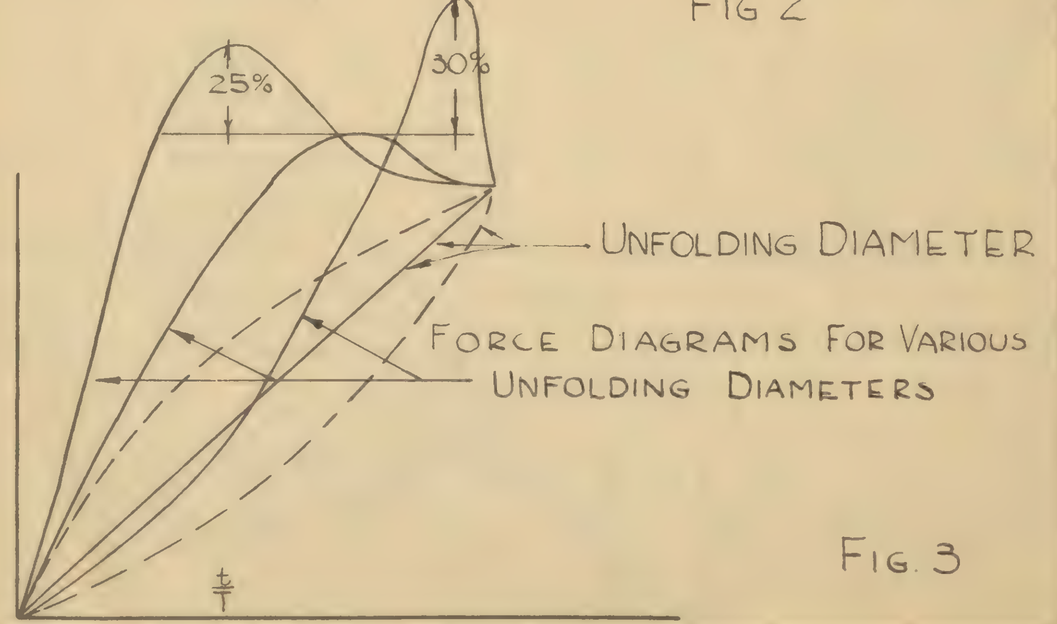


FIG. 3

there until the direction of the flow changes; it will not pendulate. Such changes of direction of flow are caused by propeller wash, winds and other disturbances in the air.

The dimensions of such a chute designed for a man weighing 100 Kg and descent of 7 meters per second is 8.5 meters in diameter and has other dimensions as indicated in figure 4. The parachute is made of natural silk or artificial silk. This material has a resistance of 16 mm water column pressure at a flow of 400 to 600 liters per second per square meter. The opening shock curves for the conventional canopy and the guide surface canopy are illustrated in the graph on page 2. The guide surface model has a lower opening shock and, according to Dr. Heinrich, is so constructed that it must open. The conventional canopy, on the other hand, may sandwich together and not open at all, or it may reach an equilibrium state of being partially open but falling too rapidly.

B. The guide parachute surface was particularly valuable for bombs. For use with parachute flares a non-pendulating chute is essential to prevent blinding of the crew which dropped them; for use with bombs to decrease the size of the bomb and thereby to increase the pay load of an aircraft; for use with parachute bombs to increase the aiming accuracy; for use with aerial mines to decrease speed so that force of impact will not injure the magnetic fuse; for use with river aerial mines to provide proper angle of impact as well as decrease the force of impact so that the mine will lie flat and be uninjured; for use with air-launched torpedoes from high speed aircraft, to slow their speed below the critical value of 300/hour.

C. In addition, Dr. Heinrich had charge of all the instrumentation for this work on parachutes. The instrumentation was not particularly novel or good, since no attempt was made to obtain methods used elsewhere, such as at the Herman Goring Institute at Brunswick.

D. Development was started and wind tunnel experiments had been completed on a parachute which has a very gradual opening shock curve. This design has a very small opening which tends to valve the air entering the canopy. The valving may be increased or decreased by placing materials of varying resistances in the throat or opening. The sketch and the (g) diagrams are on the following page.

2. Dipl. Ing. Theodor Knacke

Prof. Madelung first conceived the idea of developing a non-pendulating parachute for use to brake fast flying

aircraft for landing, aiming and other reasons. Since the conventional Irving canopy was not stable it was decided to investigate the reasons for the non-stability. These investigations were conducted by Knacke. The results indicated that the opening shock is a function of the rapidity of the parachute opening and the resistance of the cloth to the flow of gases and that the stability of the parachute is also a function of the resistance of the cloth.

A graphic sketch of the relationship of these factors is presented in figure 2 and 3 of the previous page. Figure two (2) is a plot of the increasing diameter of the parachute canopy during opening, the decrease in the velocity during opening, the increase and the acceleration or force diagram during the opening process. The diameter and the resistance curves indicate a typical over-shooting at the point where the parachute is completely open. The values for the various functions are plotted against the relative time required for the opening process, obtained by dividing the time increment by the total time required for the process.

The most ideal opening of the parachute is such that the relation between diameter increase and time of opening is a linear relation. This has been taken into account in the design of the ribbon type parachute developed by this institute. The relationship of the opening shock curve to the manner of the unfurling of the canopy is illustrated in figure 3. When the increase in diameter is faster than the ideal straight line, the opening shock reaches an early peak which is about 25% greater than the peak force which results when the opening course is linear. When the opening of the parachute is such that the unfurling is slower than the ideal, the opening shock reaches a peak relatively late, but this peak is about 30% greater than the ideal opening shock peak.

Development of the ribbon type parachute was initiated to provide a parachute which could withstand extremely high forces on opening, which are sustained from slowing down of aircraft in flight, and parachutes which are extremely stable. Such parachutes were developed successfully and the design was put to other uses, namely to the application as an emergency escape parachute for pilots of high velocity aircraft. To overcome the extremely high opening shock which develops when the parachute opens at high velocity a cord was slung through loops around the periphery of the canopy so that the size of the opening could be controlled and the air flow into the canopy could be throttled. This opening could be made very small at the

start of a high velocity jump and then increases in steps until the parachute was completely unfurled, thus producing a series of small shocks which are well below the injury threshold. A ribbon type parachute which could be immediately opened after a high velocity jump was not developed.

Development was also undertaken to provide a parachute for the paratroops so that jumps from high altitudes could be undertaken, thus minimizing the danger of flak, and yet bring the jumper rapidly and accurately into the target, thusminimizing the danger of being shot during the descent. To accomplish this the chute was provided with a small pilot parachute which unfurled immediately upon jumping but did not reduce the rate of descent appreciably below that of the free falling man but which did stabilize the fall. To bring the man close enough to the ground before opening the chute to minimize the danger of being caught in the air meant bringing him as close to the ground as possible, i.e. 300 to 400 feet. Night jumps as well as other psychological reasons ruled out the possibility of the man releasing his own chute. Barometric devices could achieve only an accuracy of + or - 150 feet and furthermore did not compensate for the topography unless previously set. Radio and acoustic devices were considered but were too complex since they involved a sender and receiver which introduced numerous servicing problems and rendered the equipment unreliable. Hence the simple expedient of a plumb line was resorted to. When the weight on this line was relieved upon striking the ground a spring was released which jerked out the parachute canopy and resulted in opening the chute. This device required considerable development but worked well on dummy parachute drops from aircraft.

To simplify the manufacture of these ribbon type parachutes the characteristics of a square canopy pattern were investigated. It was found that the square pattern was just as stable as the circular pattern and had similar unfurling characteristics. A machine was developed which could sow one fourth of each parachute at a time, completely automatically and provide the necessary spacing of the ribbon very accurately.

3. These developments on parachutes for personnel to reduce the opening shock, increase the reliability of the parachute opening and increase the stability are of considerable interest to this investigator because of the scarcity of similar investigations in these fields by the AAF.

HEADQUARTERS
UNITED STATES STRATEGIC AIR FORCES IN EUROPE (REAR)
Office of the Surgeon
Aero-Medical Research Section

AAF 390, APO 413
2 July 1945

SUBJECT: Interrogation Report.

PERSON INTERROGATED: Prof. Dr. Georg Hans Madelung.

RESULTS:

1. Prof. Madelung confirmed the statements of Dr. Heinrich and Herr Knacke, which are reported elsewhere.

2. Prof. Madelung revealed the location of other places where personnel and equipment were dispersed. These are:

(a) Dr. Sney at Niedersondhofen.
(b) Dr. Fisher - Alat See bei Füssen.
(c) Herr Rühle - Cöppingen Airdrome.
(d) Dr. Hütter - Flugzeugbau Kittelberger in Höchst bei Bregenz or im Salzburg by his father, city architect.
(e) V-1 launching ramp for testing cargo parachutes located in quarry near Maulbronn Monastery, on way to Bruchsaal 50 miles west of Stuttgart.

3. Dr. Madelung indicated that the great tensile strength permits the ribbon type parachutes to sustain greater loads. Hence, it is his opinion that a ribbon type 'chute plus a smaller 'chute for orientation are the answer for high velocity bail-out.

4. Dr. Schule, who worked with measuring techniques and with acoustic fuses, lives in Weiblingen, a small village near Stuttgart.

VERNON J. WULFF
1st Lt., Air Corps

37189-2

SUBJECT: Interrogation Report.

PLACE : Residence of Prof. Theodor Benzinger on the road between Weilheim and Schopfloch.

RESULTS OF INTERROGATION:

1. Dr. Benzinger has been at the Experimental Station, Rechlin, working with problems of aviation medicine since 1943. Since that time he has worked on the following problems:

a. High altitude physiology.

Instrumentation was developed for the continuous analysis of the last part of the expired air and obtain measurements of carbon dioxide and oxygen content. With this apparatus a series of experiments were started to determine the basis of high altitude sickness. The result of a long series of experiments indicated that the mechanism of gas exchange in the lungs could not account for all the observed phenomena and chemical or reflex phenomena were postulated. The urgency of wartime research never permitted these chemicals or reflex factors to be isolated.

b. Oxygen Consumption Under Simulated Flight Conditions.

Measurements of oxygen consumption were made in low pressure chambers and during actual flight under various work loads to determine the capacity of the oxygen installation for the various aircraft.

c. High Altitude Acclimatization.

Dr. Benzinger was interested in this problem for two reasons; first, a real gain in high altitude tolerance could be gained by acclimatizing to high altitudes and secondly, this acclimatization provided an excellent opportunity for skiing and mountain climbing for the pilots, which was urgently needed to provide a change and at the same time a method for keeping fit. The acclimatization which results from a two week stay or longer at altitudes of 6000 feet or higher will last for about three weeks after return to lower altitudes, but can subsequently be regained in shorter time intervals. This acclimatization can be explained by the following factors:

(1) A greatly increased sensitivity to oxygen lack, which results in an increased rate of ventilation even before an unacclimatized person will be conscious of an altitude change.

(2) Increased pulse rate and an increased rate of cardiac output. This is temporary and disappears as soon as the pulmonary ventilation has reached an equilibrium value.

(3) Increased hemoglobin. This is a real change and can be detected as long as the acclimatization persists. All these factors together do not completely account for the magnitude of the acclimatization.

(4) Hence, other factors are introduced - nervous reflex or circulatory factors, such as better circulation to the brain. There also exists the possibility that better capillarization exists, such as is postulated by Opitz in his tension gradient theory between tissue and arterial blood.

d. Pilot Test for Resistance to Oxygen Lack.

This test was devised by Dr. Benzinger to weed out those people that exhibit a collapse reaction and fainting upon being exposed to an oxygen lack. This collapse reaction occurred in about 2 or 3% of the cases tested. This study and examination pilots initiated considerable research in the physiology of collapse, such as the inhibitory discharges of the vagus nerve which slow down the heart and induce the fainting reaction. In this connection Dr. Weltz also has the theory that the fainting reaction in most people results from a situation of helplessness, and that an occupation or diversion suddenly thrust upon such people at the critical period will divert this fainting reaction. Prof. Jarisch at the Department of Pharmacology of the University of Innsbruck has done a lot of work on the physiology of the heart and the fainting reaction.

e. Aero-Embolism.

Investigations were conducted on the physiology and the physics of the bends and certain relationships were obtained between the incidence of bends in the ascending diver and in the ascending pilot. The precautionary measures used in the German Air Force were similar to those used by the AAF.

f. Explosive Decompression.

Numerous and exhaustive experiments on explosive decompression were performed on voluntary human subjects. Out of several hundred cases there have been a few cases of spoplexy, resulting from a closed glottis or respiratory tract during the rapid pressure drop. Outside of this danger, which exists at all times when the pressure drop is not expected, there exists only the danger of anoxia at the altitude to which the subjects are exploded. In order to prevent the loss of consciousness of aircrew members who are exploded to altitudes up to 16000 meters an automatic diving mechanism was to be introduced into all such high flying pressurized cabin aircraft which would automatically dive the craft to a safe altitude and automatically bring the plane into level flight. Such an automatic apparatus was believed not beyond the realm of possibility. In addition, an emergency pressure suit, which would automatically inflate only upon a sudden drop in pressure, was considered but did not pass beyond the experimental stage. Such a suit was to be light and was not to restrict the movement of pilot and aircrew members during normal flight. Other types of pressure suit which could replace the pressure cabin were not considered practical by Dr. Benzinger.

g. Death from Detonation.

Dr. Benzinger worked on the physiological effects of detonation and determined that death is always the result of aero-emboli which form in the carotid blood vessels and in the blood vessels of the heart. Such death usually results only when pheumothorax or severe pulmonary damage occurs. When the latter is not the case, death usually does not result. Measurements made of the blood pressure in the carotid artery and in the right ventricle indicate some increase in the pressures but not a damaging increase. The EKG which results when fatal injury takes place is similar to the EKG course which ensues from severe oxygen lack. The effect of the blast is injurious only to those organis and the neighboring organis which contain gas.